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TABLE OF CONTENTS.

LEADING ARTICLES: Page

Pacific Type Locomotive for Heavy Express Service on the Pennsylvania R. R. (illustrated) 671

Steel Cars for Passenger Train Equipment; Pennsylvania R. R. (illustrated)... 671

The Effect of High Temperatures on Lubrication by Lard and Machine Oils (illustrated); W. K. Jervis..... 675

American Society of Mechanical Engineers' Standard Proportions for Small Machine Screws (illustrated) 676

Results of the Use of Different Valve Gears on Locomotives..... 676

The Use of Alloy Steels in Automobiles; Elwood Haynes..... 677

A Wedge Splice for Ransome Twisted Reinforcing Rods (illustrated)..... 679

The Work of the Ohio State Board of Health on Water Supply and Sewage Disposal 679

An Extensometer for Recording Deformations in Bridge Members Under Impact Stress (illustrated) 681

The Piney Branch Concrete Arch Bridge at Washington, D. C. (illustrated); W. J. Douglas 682

Recommendations as to Practice in Locomotive Lubrication..... 683

Street Railway Track and Paving at Fort Wayne, Ind. (illustrated)..... 684

Locomotive Fireboxes with Expansion Side Sheets (illustrated)..... 689

The Fortieth Annual Convention of the Railway Master Mechanics' Association at Atlantic City..... 694

Engineering Works and Surveys in the Philippine Islands (illustrated); G. R. Putnam, M. Am. Soc. C. E..... 694

Examination Questions for Licensing Engineers and Surveyors in the State of Wyoming 694

A New Weldless Steel Chain (illustrated)..... 696

EDITORIAL 685

The Ohio State Board of Health—Locomotive Fireboxes—Lighter Valve Gears for Locomotives—Bridge Member Extensometers—Failure of the Milliken Brothers' Steel Enterprise on Staten Island, New York City.

The Point of Economy in the Design of Reinforced Concrete Beams (illustrated) 685

LETTERS TO THE EDITOR 688

Experience with Steel Longitudinals Under Railway Track; Gustav Lindenthal —Expansion Joints in Concrete; L. F. Bellinger—On the Application of Flat Plate Theory to Slab Floor of Reinforced Concrete; Edw. Godfrey—A Free Labor Exchange for Italians; G. di Palma-Castiglione—The Effect of the Storm of October, 1906, on the Cleveland Breakwater; C. McD. Townsend.

ENGINEERING NEWS OF THE WEEK..... 697

PERSONALS 698

ENGINEERING SOCIETIES 698

PACIFIC TYPE LOCOMOTIVE FOR HEAVY EXPRESS SERVICE ON THE PENNSYLVANIA R. R.

A trial locomotive of the Pacific type with a total weight on driving wheels of 173,550 lbs. has just been put in service on the Pennsylvania R. R., and is illustrated in the accompanying cut. It is hoped by the use of engines of this type to obviate the necessity of dividing into two sections some of the heavy through express trains.

With its six drivers this locomotive of the Pacific type can develop a traction power of 31,000 lbs., which is 22% higher than that developed by the four-driver Atlantic type engine which is up to the present time the heaviest passenger locomotive operated on the Pennsylvania R. R.

On divisions having heavy grades, trains of 8 cars have been successfully handled by the Atlantic type; but with the increasing passenger traffic 10 or 12 cars are not unusual, and as the capacity of the Atlantic type could not be sufficiently increased to meet the demands without adding considerably to the weight on the drivers, it was deemed necessary to adopt the Pacific type in order to gain the required capacity, and at the same time keep the weight on any one pair of drivers below 60,000 lbs.

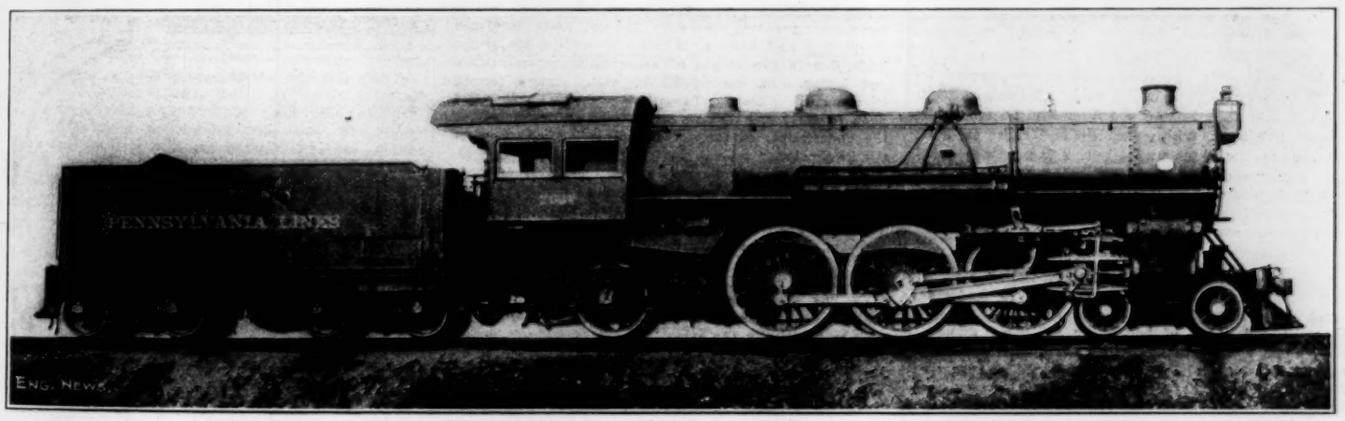
With the water in its boiler and in running condition this locomotive weighs 269,200 lbs. Its tender, when loaded with 11 tons of coal and 7,000 gallons of water, weighs 140,000 lbs.—making a total for the engine and tender of 409,200 lbs., or 204.6 tons.

In order that the locomotive might make fairly high speeds, the drivers are made 80 ins. in diameter, the same as the Pennsylvania's Atlantic type locomotive. The stroke is the same as in the Atlantic type engine, namely 26 ins.; but the cylinder diameter, 24 ins., is 2 ins. larger than the Atlantic type. Increased heating surface in the boiler is secured by using 21-ft. tubes, longer by 2 ft. than those of the Atlantic type.

The Walschaert valve gear used on this engine has been designed to bring its working parts in one plane. For this purpose a special supporting frame is provided outside of the link.

The principal dimensions and weights of the locomotive are as follows:

Cylinders	24 ins. × 26 ins.
Piston Valve	16 ins. × 7 ins.
Boiler:	
Diameter, first ring	79¾ ins.
Pressure	205 lbs.
Firebox	111 ins. × 80¼ ins.
Tubes—number	343
Tubes—diameter	2¼ ins.
Tubes—length	21 ft.
Heating surface—tubes	4,222 sq. ft.
firebox	205 sq. ft.
total	4,427 sq. ft.
Grate area	61.8 sq. ft.
Driving wheels—diameter	80 ins.
Main driver journals	10½ ins. × 14 ins.
Other journals	10 ins. × 14 ins.
Front truck wheels, diameter	36 ins.
Front truck journals	6½ ins. × 12 ins.
Wheel base—total engine	35 ft. 2½ ins.
Total engine and tender	67 ft. ¾ in.
Driving	13 ft. 10 ins.
Weights:	
On front truck	46,175 lbs.
On front drivers	59,000 lbs.
On main drivers	57,675 lbs.
On back drivers	56,875 lbs.
On trailers	49,475 lbs.
Total locomotive	269,200 lbs.
Tender	140,000 lbs.
Tractive power	31,000 lbs.
Tender:	
Water capacity	7,000 gallons
Coal capacity	22,000 lbs.



PACIFIC TYPE LOCOMOTIVE FOR HEAVY EXPRESS SERVICE, PENNSYLVANIA R. R.

A 20,000 ACRE FARM for the cultivation of railroad ties is the Pennsylvania R. R.'s proposed remedy for the failure of steel manufacturers to produce suitable steel ties and the rapid denuding of existing forest areas. The company has purchased a tract of that area on the Allegheny slope, between Altoona and Hollidaysburg, Pa., and the forest to be grown thereon will be the largest artificial one in the world's history.

It is estimated that in 40 years the tract will produce an annual yield of over 4,000,000 ties; the road at present uses over 5,500,000 ties annually. Mr. E. A. Sterling, Assistant United States Forester, has been placed at the head of the new forestry bureau of the Pennsylvania, and will shortly plant over 1,000,000 trees on the tract.

STEEL CARS FOR PASSENGER TRAIN EQUIPMENT PENNSYLVANIA R. R.

Within the past few years a number of experimental cars of steel construction for passenger service have been built at different railway and contract shops, and such construction has been practically adopted for the cars of rapid transit subway lines. The first practical step towards the general use of steel equipment in main line passenger trains has recently been taken by the Pennsylvania R. R., which has ordered the construction of 200 cars on designs worked out by its own engineers. These will include not only day cars, but also baggage, mail and dining cars. This order is by far the largest yet given for main-line equipment of this character, and the company's policy in this respect is the result of a long period of inquiry and experiment, in which the late President Cassatt took an active part. After several cars had been built, the president appointed a committee of motive-power officials to make a thorough report on the design to be adopted and the orders now placed are in accordance with the recommendations of that committee.

It is stated that when steel cars were proposed for use in the New York Subway, none of the car builders in the country were in position to furnish them, so an experimental motor car was built by the Pennsylvania R. R. at its Altoona shops. This was in 1902. In 1904 a 58-ft. passenger car was built, which had a steel underframe and a steel outside sheathing up to the roof. The interior finish was largely of composite board and the roof was of wood covered with copper. As this car contained about 1,500 lbs. of wood further development of the designs was considered necessary. The next was a 60-ft. baggage car, completed in November, 1906, and this was followed by a 70-ft. mail car turned out in February, 1907. In the two latter cars only an extremely small amount of wood was used. Designs have now been prepared for a 70-ft. pas-

senger car or day coach and a 70-ft. dining car. The former contains but 300 lbs. of wood (used for brake rod guards, window sashes and arm rests for the seats). The interior finish is of steel except the headlining, which is of composite board. Designs are being completed for a suburban passenger car, 54 ft. 4 ins. long. The baggage and dining cars are built on the same general designs as the passenger and mail cars. The company has also arranged with the Pullman Car Co. to design and build steel sleeping cars and parlor cars.

The railway company has decided to adopt two types of steel equipment for passenger service: (A) For through trains, drawn by steam or electric locomotives and composed of mail, baggage, sleeping, dining and day coaches; a long car of heavy construction suited to withstand the strains incident to pulling, coupling, or buffing in long trains. (B) For suburban trains, drawn by locomotives propelled by motors upon the truck axles, a short car of lighter construction. The principal features of these several cars are given in the accompanying table:

STEEL CARS FOR PASSENGER SERVICE: PENNSYLVANIA R. R.

Cars.	Length over buffers, ft.	ins.	Weight, lbs.	Trucks.	Capacity.
Passenger*	80	3¾	113,500	4-wheel	88 pass
Mail	74	9¾	128,000	6-wheel	.....
Baggage & express	60	10⅝†	91,000	4-wheel	40,000 lbs.
Baggage & express	70	0†	120,000	6-wheel	60,000 lbs.
Comb. pass. & bag.	71	1†	130,000	6-wheel	.....
Dining	72	0†	140,000	6-wheel	.....
Sleeping	80	6	.....	6-wheel	.....
Suburban	64	5¾	75,000	4-wheel	72 pass

*Wooden car for 62 passengers weighs 91,000 lbs.
†Length over end sills, exclusive of vestibules.

STEEL PASSENGER CAR: PENNSYLVANIA R. R.

Probably the most interesting of the new steel cars are the passenger or day coaches for main line service, and the construction of these cars is illustrated by the accompanying drawings. In general arrangement and appearance the new steel passenger cars closely resemble the company's standard wooden passenger cars, and like them they are mounted upon four-wheel trucks, but the trucks are entirely of steel. The cars are 80 ft. 3¾ ins. long over the buffers, 9 ft. 10 ins. wide over the sides, and are supported on truck centers 56 ft. 3 ins. c. to c.; the height from the rail is 4 ft. 4 ins. to the floor and 14 ft. to the top of the roof, while the inside height is 7 ft. 6½ ins. at the sides and 10 ft. 2 ins. at the middle of the monitor roof. This part of the roof is 7 ft. 7 ins. wide.

The following particulars of the design and equipment of these cars are taken from a statement issued by the railway company:

GENERAL DESIGN OF FRAMING.

In preparing the designs for heavy type equipment great care has been exercised to provide ample strength to resist end shock of buffing or collision. Standard steel freight cars are designed to resist an end shock equivalent to 300,000 lbs. compression. Experience with freight cars during the last five years has indicated that this is not excessively high. An experimental determination of this figure was made by allowing a dynamometer car, weighing 51,000 lbs., to bump a number of loaded freight cars. The dynamometer registered 607,000 lbs. Another experiment was made by allowing a loaded steel freight car and the dynamometer car, weighing together 181,400 lbs., to bump a loaded freight car. The dynamometer recorded 400,000 lbs. Impact, of course, cannot be measured in pounds, but the results give a general idea of the conditions of actual service. In collision between passenger and freight cars it is desirable that the passenger car should be the stronger in order to escape with as little injury as possible.

In computing loads upon the various members of the frame, it has been decided that a compression load of 250,000 lbs. between buffers, also 150,000 lbs. between draft gear, is to be added to the normal loads due to the weight of the car and lading. Under these conditions the combined fiber stress is limited to 12,500 lbs. per sq. in. for cars in through train service, and 20,000 lbs. per sq. in. for cars in suburban service. In determining these stresses, none of the material above the belt rail is included. The sides of the cars beneath the window sills form girders about 3 ft. deep, for which the belt rail acts as the top flange and the side sill as the bottom flange. Owing to their great length, the thinness of the web, and the comparative shallowness of the flanges, these girders would probably collapse if subjected to end thrust. In calculations, therefore, the web and upper flange are not considered as resisting any of the

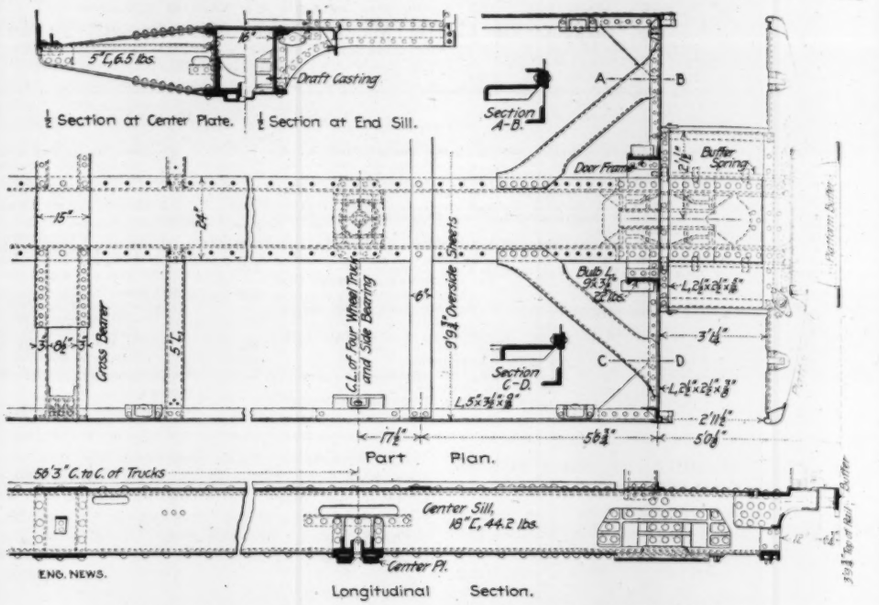


FIG. 1. UNDERFRAME OF STEEL PASSENGER CAR; PENNSYLVANIA R. R.

400,000 lbs. load assumed to represent the effect of buffing.

The superstructure is made of such strength that the cars can roll completely over without danger of collapse. Posts, carlines and other parts are proportioned under this assumption. The ends are framed with the idea of preventing one car from sweeping off the superstructure of the next one, should the underframe of one rise above the floor of the other in a collision. Deck or I-beams forming a frame about the end door, and securely fastened to both underframe and roof, are provided with this idea in view.

In the design of framing for steel cars two general types have been developed. In one, the center sill is made strong enough to resist the end loads developed by pulling and buffing, in addition to the transverse loads due to the weight of underframe, superstructure and lading. In the other, the plate girders formed by the sides of the car beneath the windows are relied upon to carry the transverse load due to the weight of the underframe, superstructure and lading. The center sill in the latter type is usually rather light, being designed to resist only the end loads developed by ordinary pulling and light buffing. This type of framing follows the general form used in wooden cars, where the transverse loads are carried by wooden trusses within the sides of the car reinforced by truss rods beneath the side sills.

By careful calculation it has been found that when the loads due to pulling and buffing are less than 100,000 lbs., the weight and cost of a car frame of either type will be practically the same. Where these loads exceed 100,000 lbs., the framing for the type in which the sides carry the load increases considerably in weight. With the center-sill type, the loads may equal the assumed value of 400,000 lbs. without a material increase in weight. For cars in through train service, subjected to heavy buffing and pulling, the center-sill type of frame has been selected. It has also been used in designs for suburban type equipment, as it has been found that, with a modified form of center sill, sufficient room for the motors can be provided between the underframe and track.

The height from the track to the center of coupler is determined by law and the height to the top of the floor is practically regulated by custom. The center of the drawbar is therefore fixed at about 17 ins. below the floor.

In wooden passenger car construction the center sills are usually rather shallow and the coupler is supported below them. Loads upon the underframe, brought about by buffing, tend to bend down the ends of the car due to the fact that the center sills are not symmetrically loaded. In the steel car of the through train type the center sill is made deep enough to bring the line of the coupler within its section.

With the heavy center-sill frame, body bolsters are unnecessary, for the major part of the transverse load is delivered directly to the center sill which transmits it to the trucks through the center plates. The transverse loads which come upon the sides of the car and which must be transferred to the center girder are delivered to it at four points to equalize the loading. The two points of application of the concentrated loads at each end are so selected that the two loads are about equidistant from the center plate. Under this condition it has been possible to obtain in the center sill practically equal fiber stress at the middle and over the center plates, thereby securing great economy in metal and avoiding the use of a center sill of deeper cross-section at

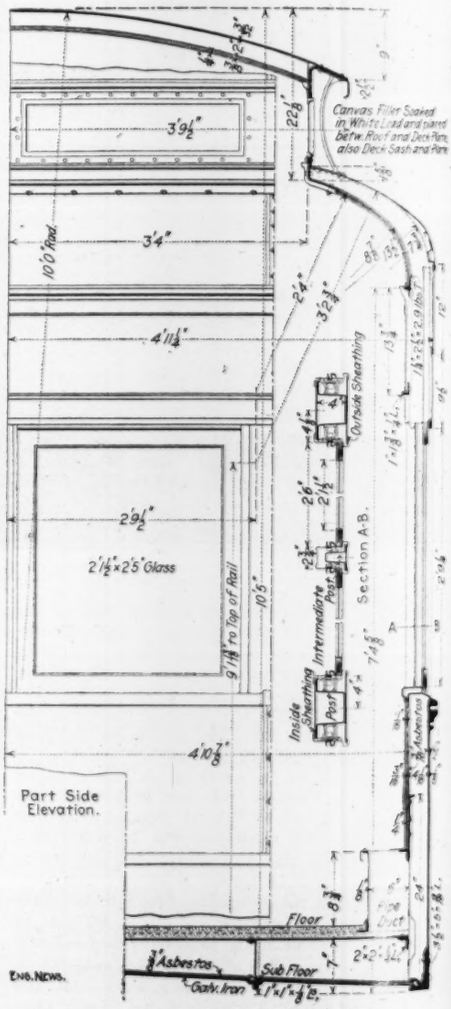


FIG. 2. CROSS-SECTION SHOWING BODY AND ROOF FRAMING AND FLOOR CONSTRUCTION OF STEEL PASSENGER CAR; PENNSYLVANIA R. R.

the middle than over the trucks. By the symmetrical loading of the center sill each of the four points is deflected practically the same amount. They therefore are always in line with one another and no load is placed upon the superstructure of the car by the deflection of the center sill. With the comparatively thin sheet metal used in sheathing the sides and roof it is of great importance to avoid unnecessary loading, as it is likely to cause loosening of the joints and working of the rivets in their holes. With this form of construction the side girders can be made comparatively light as they sustain little transverse load and are supported at four points. Side doors required by mail, express, or baggage cars can be located where most convenient without requiring any material strengthening in the side truss.

UNDERFRAME.

The underframe construction is shown in Fig. 1. The center sill is a box girder formed by two 18-in. 42-lb. steel channels, with top and bottom cover plates ½ × 24 ins. Cast steel center plates are riveted to the underside of the sill, which is reinforced at these points by steel castings riveted inside. Projecting beyond each end of the center sill are steel castings designed to transmit directly to the sill the loads due to buffing, and to support the spring rods carrying the vestibule buffer plates. These castings are provided with projecting lugs and flanges to which the platform end sills and vertical channels forming vestibule posts are riveted. Within the center sill near each end are riveted steel castings arranged to carry the couplers and draft gear.

The side sills are of angles 5 × 3 × 9/16 ins. Each sill is supported by the end sills, and at two intermediate points (about 14 ft. from each end) by cross bearers. The end sills are of the cantilever form, riveted to the central girder and built up of angles, the outside sheathing plate acting as the web.

The cross bearers are also of the cantilever form, each composed of two triangular web plates flanged about the edges, and riveted at their base to the center sill. Opposite cross bearers are joined by cover plates which pass over and under the center sill. Each side sill is held in line by nine transverse struts of 5-in. channels connected to the center sill. These struts do not transmit any vertical load from the side sills to the center sill. Cast steel side bearings for engaging the trucks are secured to the side sills.

SUPERSTRUCTURE.

The character of the body framing and superstructure is shown in Fig. 2. Pressed steel posts spaced 5 ft. 11 ins. c. to c. form the main support of the superstructure. They are of channel section and the edges are flanged out and riveted to the inside sheathing, forming a box section, as shown by the detail section in Fig. 2. The lower ends are securely riveted to the side sills and the upper ends are tapered down and bent inward to form lower deck carlines. At their upper ends these posts are riveted to the plate carrying the deck sash. The lower edge of this plate is bent out beneath the ends of the posts and forms a continuous beam of angle section running the entire length of the superstructure. Between the main posts are shorter and smaller intermediate posts, which extend only from the window sill to the plate carrying the deck sash. They are of light channel section, with edges flanged for riveting to the outside sheathing, forming thereby a box section as in the main posts.

The upper deck carlines are of sheet steel pressed to channel section, with edges flanged out for riveting to the 5/32-in. steel roof-plate. Their ends are riveted to the plate-carrying the deck sash. The upper edge of this plate is bent outward and down, forming a continuous beam of channel section, to which the edge of the roof-plate is riveted. Malleable iron braces unite the end of each post and its corresponding carline.

The outside sheathing is of ⅛-in. steel, and the course below the belt rail is riveted to the side sill and to each post. The steel shape forming the under sill for the windows laps over the side sheathing, and rivets passing through the belt rail (which runs the entire length of the car) secure this joint. Outside sheathing above the windows is riveted to the posts and its upper edge is riveted to a channel-shaped steel section forming the eaves for the lower deck and extending the entire length of the superstructure.

The headlining for the upper and lower decks is of composite board secured to the carlines and posts with metal strips. Below the belt rail the inside sheathing is of 1/16-in. steel, to the unexposed face of which a 3/16-in. asbestos lining is cemented. The bulkheads and remaining parts of the inside lining are of 1/16-in. sheet steel. Moldings, closely resembling those used in wooden construction, are pressed from steel. Through care in design it has been possible to almost wholly eliminate machine screws from the construction, and it is believed that economy in both construction and maintenance has been secured thereby.

The window sashes are of wood and slide in formed steel frames. Steel sashes have been successfully built, but after careful consideration, wood was deemed preferable. Malleable castings riveted to the posts support the window frames. These castings are machined by jig, after riveting in place, so that the frames will be true and parallel regardless of any slight irregularity in the location of the posts. Window stops, which also form ways for the curtains, are of extruded bronze. The deck sashes are of malleable iron.

The floor is formed by corrugated steel plates which are supported by the center sill and upon longitudinal shelf angles secured to the side posts. These plates are covered to a maximum depth of 1½ ins. with a plastic surface filling, composed largely of cement. A sub-floor of asbestos ⅝-in. thick, supported by No. 20 galvanized sheet steel, is secured to the center and side sills. Along each side of the car, just above the floor, rectangular ventilating ducts are provided; these enclose the heating pipes and discharge warmed fresh air into the car.

In the platform and vestibule construction, Fig. 3, an effort has been made to secure sufficient strength in the end of the car to prevent the superstructure from being swept off from the underframe by the next car in event of a collision. The center sill is the main support of the entire vestibule and to it are securely framed the 9-in. bulb angles forming the end door frame, together with the 5-in. channels forming the vestibule posts. These vertical members are relied upon to prevent damage to the superstructure in case of collision. The vestibule floor plate, the end sills and sheathing, and the vertical bulb angles, are securely framed together to give an exceptionally strong foundation for the entire end construction.

Vertical corner angles uniting with the sides, and an angle across the top secured to the vestibule ceiling, form the support for the end sheathing. Two diagonal braces running from the eaves down to the floor, and securely riveted to the sheathing give additional stiffness to the ends. The end of the vestibule is supported by two outside posts of pressed sheet steel, together with two channel posts forming a doorway. The base is formed by a pressed steel platform end sill, and the top support is given by the vestibule ceiling plate. Door jambs and lintels are of pressed steel, closely imitating the forms used in wooden construction. These are provided with cast diaphragms at intervals to prevent collapse and furnish support for attaching hinges, railings, etc. The end construction of the roof is of formed steel plates, reinforced by angles secured to the end carline and the vestibule ceiling.

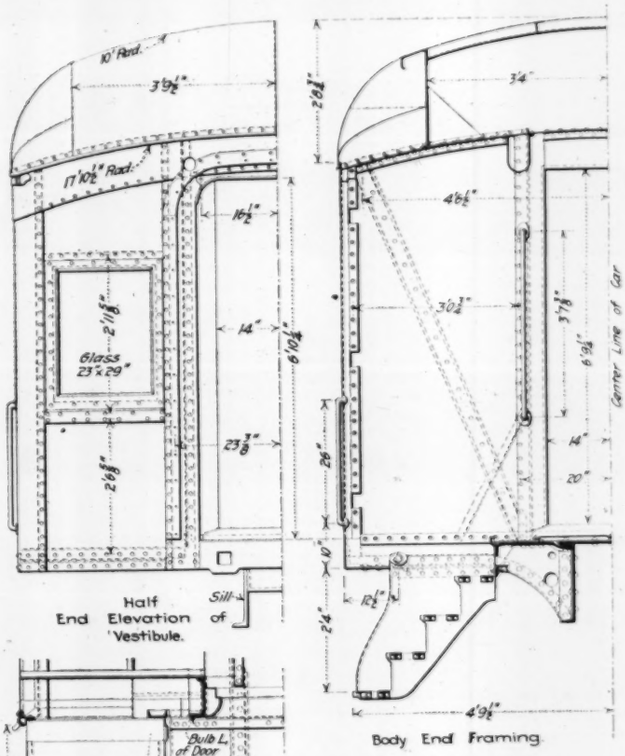


FIG. 3. END FRAMING OF STEEL CAR.

SIX-WHEEL TRUCKS.

While the day cars will have four-wheel trucks, some of the other types of cars will have six-wheel trucks, as already noted. These are shown in Figs. 4 and 5. An entirely new form of truck was required for the steel cars, owing to the fact that the deep center sill of the underframe lowered the center plate until it just cleared the middle axle of a six-wheel truck. Advantage was taken of the opportunity offered for redesign, and a truck based upon new principles was evolved, which is applicable either to motor cars or to those drawn by locomotives. Although it is designed to carry a load equivalent to the maximum capacity of the 5 × 9-in. axle it weighs only 19,500 lbs., while the wooden truck weighed 21,700 lbs. Transoms, spring planks and equalizers are not required, as their functions are covered by other elements in the new principle of design. The wheelbase is 11 ft.

The construction of the truck is shown in Fig. 5. Two elements are embodied; the rectangular frame carrying the wheels, and the bolster which transmits the load delivered at the center plate to the axles through the spring rigging. The axle runs in boxes of the usual type, which slide vertically in pedestals, secured to the wheel pieces and connected at their bottom ends by pairs of tie-bars. Sufficient space is allowed between tie-bars to permit the use of a jack in removing bearings. Each wheel piece or side frame is composed of two 10-in. channels (with their flanges turned inward), separated to permit certain of the working parts to go between them, and secured to one another at intervals.

The two wheel pieces are held together by four pressed steel cross members of channel section, one at each end of the wheel pieces and one on either side of the middle wheels. They are depressed below the bottom of the wheel pieces in order to clear the center sill of the underframe of the body.

The truck has two bolsters connected by girders carrying the center plate, thus forming one member. This double bolster is composed of four girders running across the truck, to the top of which are secured two girders A running lengthwise of the truck. The center plate rests upon the two short transverse girders B of pressed steel. The lower flanges of these girders are turned up at the ends, and the plate riveted to the lower flange is brought up and riveted to the longitudinal girders A. Between the girders B is riveted a reinforcing casting to transmit the load delivered by the center plate. The drawings show the construction and indicate how the lower face of this casting is shaped to clear the axle. A horizontal rectangular plate forms the lower flange of both girders A and acts as a diaphragm to square the bolster. Spring beams C are riveted to the under side of girders A and to the rectangular plate which forms their lower flanges. They extend on both sides beneath the wheel pieces and are confined between guides D, which allow only vertical and transverse motion of the bolster with reference to the truck frame. The spring beams C are of sufficient width to admit four elliptical springs between their downwardly projecting legs.

The entire load borne by the truck is delivered by its bolster to 16 elliptical springs which rest upon equalizers having a ratio of 2 to 1. The equalizers are suspended from hangers E which deliver to each box of the middle axle one-sixth of the entire load borne by the truck and to each wheel piece one-third of the entire load borne by the truck. This load is delivered to the wheel piece at two points near the outside pedestals so that each box of the outside axles receive one-sixth of the entire load borne by the truck. Each box receives its load through a nest of three helical springs, which in the case of the end axles, bear upon castings secured to the wheel pieces, and in the case of the middle axle, bear upon short equalizers or yokes F, which rest on the boxes and are connected to the hangers E. The boxes, of the middle axle, therefore, move up and down freely and without any connection or relation to the wheel pieces.

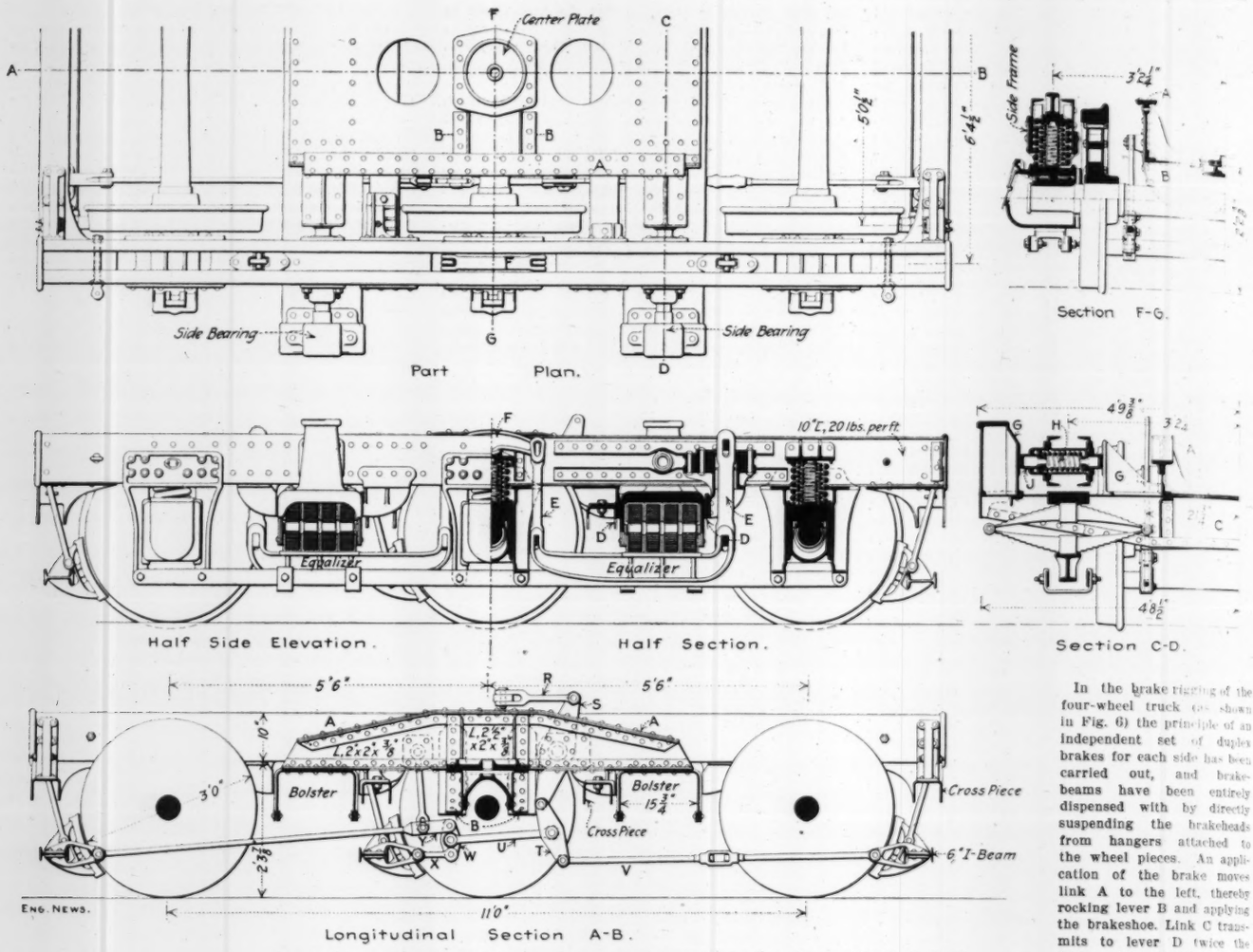


FIG. 4. SIX-WHEEL TRUCK FOR STEEL PASSENGER CARS; PENNSYLVANIA R. R.

Side motion of the bolster relative to the wheel pieces is provided for by the hangers E and guides D, but is limited by the abutments G secured to the spring beams. Helical springs H, resting upon followers J guided by the wheel pieces and engaging the abutments G, G, centralize the bolster and give easy riding qualities equal to those secured by the link suspension generally used on wooden trucks. The outer abutments also act as side bearings for the car body and engage castings secured to the outside sills.

FOUR-WHEEL TRUCKS.

The four-wheel trucks for the day cars and smaller baggage cars are similar to the six-wheel trucks in general design. As shown in Fig. 6 the frame is the same, except that the wheel pieces are connected by only two cross members instead of four. The two spring-beams of the six-wheel truck are consolidated into one, and the longitudinal girders A and transverse girders B (which become unnecessary) are eliminated. A single bolster is used, of channel section, reinforced at the middle for the center plate and broad enough to cover six elliptical springs. The truck has only one side-bearing on each side.

The entire load borne by the truck is delivered by its bolster to 12 elliptical springs which rest upon carriers suspended from hangers which are hung from the wheel pieces. No equalizers are necessary as the wheel pieces perform that function. Each axle box receives its load through a nest of three helical springs, which bear upon castings secured to the wheel pieces, in the same way as for the outside axles of the six-wheel truck. A considerable saving in weight is effected by the use of steel construction. The steel truck weighs 12,500 lbs., while the wooden truck weighs 16,000 lbs. The wheelbase is 7 ft.

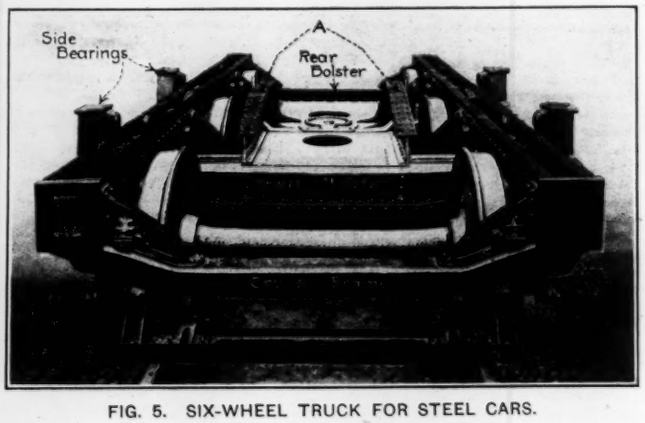


FIG. 5. SIX-WHEEL TRUCK FOR STEEL CARS.

BRAKE RIGGING.

In redesigning the trucks, careful consideration was given to the brake rigging. For the six-wheel truck a system was devised embodying the principle of an independent set of triple brakes for each side of the truck, which apply their braking force to the brakebeams adjacent to the brakeheads, thereby avoiding heavy bending strains usually present in brakebeams. The brakes of each truck (Fig. 4) are connected to the ends of horizontal equalizers by links R. Application of the brakes moves the link to the left, thereby rocking lever S about its center and transmitting motion to lever T. This pulls rod U with twice the force of rod V, which acts upon a brakebeam. Through equalizer the pull of rod U is divided equally between rods X and Y, which directly act upon their respective brakebeams.

In the brake rigging of the four-wheel truck (as shown in Fig. 6) the principle of an independent set of duplex brakes for each side has been carried out, and brake-beams have been entirely dispensed with by directly suspending the brakeheads from hangers attached to the wheel pieces. An application of the brake moves link A to the left, thereby rocking lever B and applying the brakeshoe. Link C transmits to lever D twice the force with which the first brakeshoe was applied. One end of the link E is pivoted to the wheel piece of the truck, so that lever D rocks about its upper end and the force delivered to its brakeshoe is half the thrust of link C, thus equaling that delivered to the other brakeshoe. All cars have hand-brake attachments.

DRAFT RIGGING.

It was found upon careful investigation that the standard form of drawbar and coupler heretofore used on wooden cars did not allow sufficient side motion of the coupler head in rounding curves. The resultant binding was particularly noticeable upon long cars and to remedy the defect an entirely new arrangement was devised by means of which a lateral motion of S ins. on each side of the center was secured.

The construction and operation of the draft rigging are shown in Fig. 7. The drawbar A at its inner end is connected to the draft gear by pin B and at its outer end is connected to the coupler head by pin C. The socket of the coupler head, into which the drawbar enters, is broad enough at its end to allow considerable rotation of the coupler head with reference to the drawbar about the pin C.

Pivoted about pin C, between the two jaws of the drawbar, are levers D and E. Their outer ends are pressed apart by the helical spring B and engage faces formed by the vertical webs of the center sill. Secured to the drawbar is pin F which engages lugs G and H upon levers D and E. The outer edges of these levers engage the inner faces of cavity in the coupler head. The helical spring serves the double purpose of centralizing the coupler head with reference to the drawbar and also of centralizing the drawbar with reference to the center sill.

If the coupler head should be rotated about its pivot so that the outer end would move to the left, lever E would be rotated at the same time due to its engagement with the inner face of the coupler head socket. This motion would compress the helical spring, which would tend to restore the coupler head to its center position as soon as the acting force was removed. A movement of the character just described would probably take place in coupling if the couplers were not in perfect alinement with one another.

In rounding a curve, the drawbar pivots about pin A.

giving outer end a lateral motion. If the outer end of the drawbar moved to the left lever E, due to its engage with the center sill, would rock about pivot C tow the center line of the drawbar. This would compr the helical spring, which would tend to restore the dr ar to its mid-position as soon as the acting force removed. During the action just described, lever D would not move with relation to the drawbar, as its lug G would engage pin F due to the thrust exerted by the helical spring.

In the uncoupling device, a large amount of side motion given to the coupler head would require considerable slack in a chain connecting with the uncoupling lever upon the platform. To avoid possibility of trouble from this source, bell crank levers, S and T, coupled by rods U, V and W, have been introduced into the connection with the uncoupling lever. Their form and points of application have been so chosen that any motion of the coupler head will not affect their successful operation.

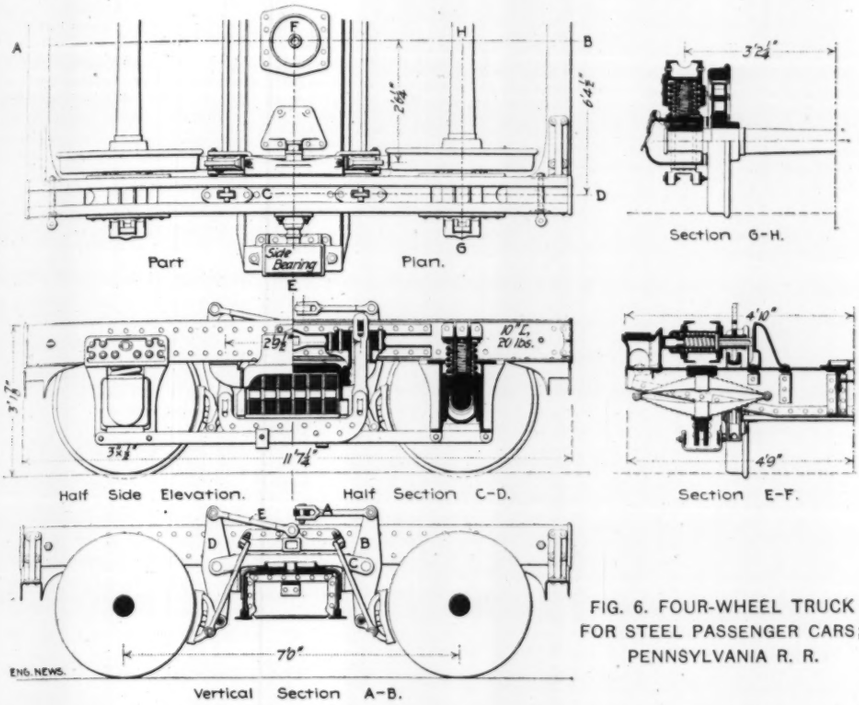


FIG. 6. FOUR-WHEEL TRUCK FOR STEEL PASSENGER CARS; PENNSYLVANIA R. R.

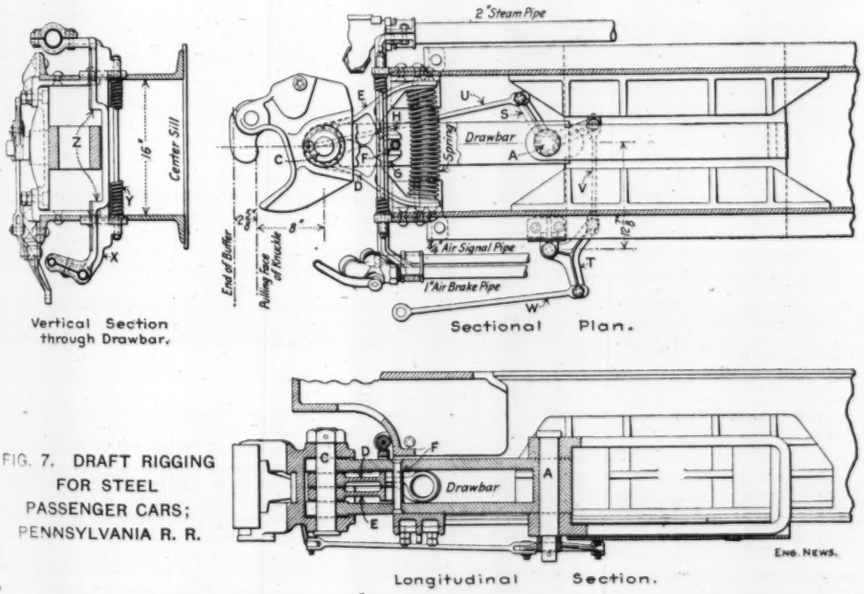


FIG. 7. DRAFT RIGGING FOR STEEL PASSENGER CARS; PENNSYLVANIA R. R.

Owing to the large amount of side motion, the coupler heads would interfere with steam and air pipe valves in their regular position. A yoke X has been provided, which slides laterally in bearings, and to which the ends of these pipes are secured. A helical spring Y maintains this yoke in its central position, and it is moved laterally (when the drawbar moves) by the sides of the drawbar engaging lugs Z on the under face of the yoke.

VENTILATING, HEATING AND LIGHTING.

These passenger cars will be equipped with a ventilating system by which, with all windows and doors closed, 1,000 cu. ft. of fresh air per hour per passenger will be supplied, which is equivalent to a complete change of air in the car every four minutes. The comparatively small volume of air in a coach, and the large number of passengers carried, renders the ventilating problem particularly difficult. To change the air completely every four minutes without producing drafts of any kind is a problem in itself, and it is made more difficult by the fact that in cold weather all of this air must be thoroughly warmed before it enters the car. The system employed was developed after careful experiments covering a period of years and has been successfully used in over 1,000 wooden cars.*

Air is taken in by two hoods situated at diagonally opposite corners of the roof. From each hood a vertical duct leads down inside to a horizontal duct which runs the entire length of the car, between the floor and the sub-floor, next to the side sill. Above the floor of the car, and running its entire length along the sides, are rectangular ducts containing the steam heating pipes. Air entering the hood passes down to the duct beneath the floor and along this to openings into the duct containing the heating pipes. After circulating about the pipes and becoming thoroughly warmed it is delivered into the aisle of the car through tubular outlets beneath each seat.

Air is discharged from the car through ventilators in the roof, which are provided with valves to limit the amount of air passing. Movement of the car forces the air into the car under slight pressure; limiting the discharge maintains the pressure and prevents the entrance of cold air through cracks about the doors and windows. The ventilation system works equally well in either winter or summer, but the warming of so much fresh air requires considerably more steam than would be needed by the usual methods of heating without much if any ventilation.

In the suburban cars heated by electricity it will be impracticable to supply sufficient heat to warm the great volume of air required for ventilation, and these cars will, therefore, be ventilated in the usual way, by opening windows or ventilating sashes on the roof. It is expected that this will prove satisfactory, as passengers in this service usually make trips of comparatively short duration.

The steel cars will be lighted entirely by electricity, current being furnished by storage battery, trolley connection, axle generators, or train generators as the conditions may require. Incandescent lamps will be used for side lights and in the toilet rooms, while in the body of the car special lamps and reflectors will be employed.

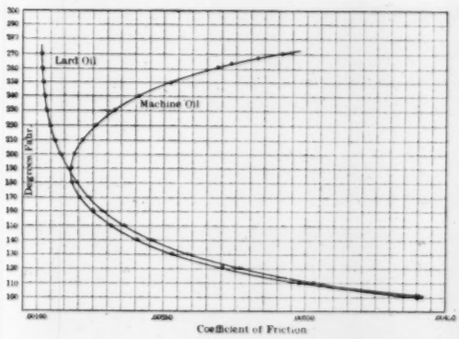
*Engineering News, Sept. 29, 1904.

THE EFFECT OF HIGH TEMPERATURES ON LUBRICATION BY LARD AND MACHINE OILS.*

By W. K. JERVIS.

Experiments were run for the purpose of determining the effect of higher temperatures than ordinarily occur upon the friction set up in a given bearing by the oil film between the rubbing surfaces, pressure and speed being maintained constant. The oils experimented upon were common lard and machine oils such as are used for cutting and lubricating purposes. The results obtained are doubly interesting because of the rather extreme conditions of pressure, speed and temperature under which the test was run, and because of the remarkable regularity with which the points, when plotted, fall on a smooth curve.

A Kingsbury oil testing machine was used, in which a vertical spindle ran between two opposed brasses in a bath of the oil under test, which was contained in a surrounding cylindrical case. The load on the bearing was applied by a heavy helical spring, passing through the side of the case and adjusted by a screw.



Curves Showing the Results of Lubrication Tests on Lard and Machine Oils at High Temperatures.

The oil case and its attachments were mounted upon a hollow vertical spindle free to turn on the frame of the machine. The moment of friction of the journal tending to rotate the case was balanced by the torsion set up in a tempered-steel wire by which the hollow spindle was supported, and the displacement of the case was read off in degrees from a circular arc on the frame of the machine. Heat was applied to the case and contents by means of a gas flame.

The results are shown in the accompanying curve. Up to about 180° F. the coefficients of friction of both the lard and machine oils run very nearly together, the difference being about 3% in favor of the machine oil. As the temperatures increase, producing a corresponding decrease in the viscosity of the oils, the curves show that the friction coefficients become less, reaching a minimum at 190° for the machine oil, but continuing to decrease as much as 10% more with the lard oil, the curve becoming nearly asymptotic to the temperature axis and showing no sign of change up as high as 280°

Evidently above 190° the machine oil disintegrates and the film between the bearing surfaces begins to break down; hence the friction increases very rapidly with the temperature.

*Extracts from an article in the "American Machinist," of May 9, 1907.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD PROPORTIONS FOR SMALL MACHINE SCREWS.*

The standard diameters for Machine Screws shall be the 21 sizes given in Table I.

The included angle of the thread shall be 60°, with flat at top and bottom of the thread for the *basic standard* of one-eighth of the pitch.

The uniform increment between all sizes from 0.160-in. to 0.190-in. is 0.013-in., and between 0.190-in. and including 0.450-in. is 0.026-in. The pitches are a function of the diameter, as expressed by the formula:

$$\text{Threads per inch} = \frac{6.5}{D + 0.020}$$

and the results are given approximately and in even numbers in order to avoid the use of fractional or odd-number threads.

SCREW LIMITS.—The *maximum screw* shall conform practically in all respects to the basic standard. The *minimum screw* shall have a flat at bottom of the thread of one-sixteenth of the pitch. The difference between the maximum and the minimum root diameter will allow at bottom of the thread any width of flat between one-sixteenth and one-eighth of the pitch, thus providing allowance for variation. [See diagram Fig. 1].

TAP LIMITS.—The *maximum tap* shall have a flat at top of the thread equal to one-sixteenth of the pitch. The difference between maximum and minimum external diameter will allow at the top of thread of tap any width of flat between one-sixteenth and one-eighth of the pitch.

The *minimum tap* shall conform to the basic standard in all respects except diameter, as clearly shown by the diagram Fig. 1. The difference between the minimum tap and the maximum screw provides an allowance for error in pitch, or lead, and for the wear of tap in service.

The form of tap thread shown in the diagram is recommended as being stronger and more serviceable than the so-called V-thread, but it has been suggested that strict adherence to the form shown might, in the case of small taps, add to their cost. However, taps with V-threads and with the correct angle and pitch diameters, used in connection with tap drills of correct diameter are permissible. This will also utilize a large proportion of the V-thread taps now in stock.

Table II. gives formulas for determining the limits of variation found practical for screw and tap diameters. The limiting diameters recommended for both screws and taps are given in Table I. The formulas and the tabulated values provide an allowance for variation of pitch as well as for the diameter of screw and tap.

The screws here considered are those known as pressed head machine screws; are manufactured in great quantities, and are listed and sold to the trade by the gross. The formulas, however, apply equally well to the diameter of corresponding sizes if made by machine operation from stock which is the diameter of the required head. The formulas for heads [not reproduced here.—Ed.] are for pressed head screws only.

Table III. gives the thickness of double end templet thread gages for each pitch of the standard screws recommended for the practical inspection of machine screws. The formula

$$\text{Thickness} = 1.443 \sqrt{\text{Pitch}}$$

gives the maximum limit for screws, and provides also a limit for the error in lead of screws and taps.

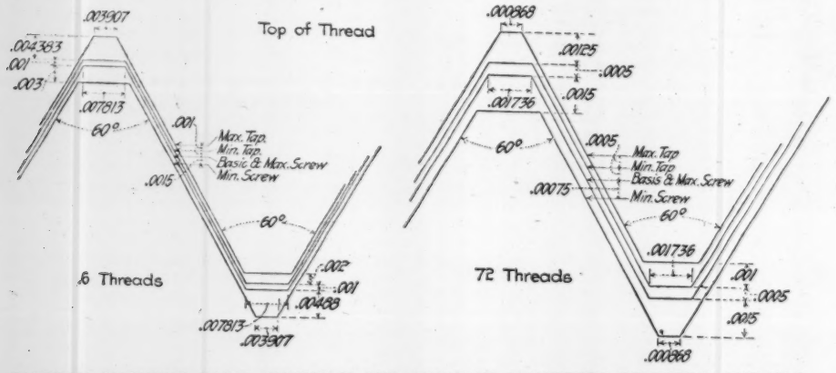


DIAGRAM SHOWING BASIC, MAXIMUM AND MINIMUM DIAMETERS OF SCREW AND TAP; AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD.

These templet thread gages to be made of steel, hardened, and double end, with maximum and minimum limits, respectively, and to represent accurately at the plus end the pitch and root diameters of the basic standard; while at the minus end they should represent the minimum limit for the pitch and root diameters of screws. The threads of these templet gages to be made by taps having the thread enough larger than standard in outside diameter to insure clearance at the top of the thread of the screw. In addition to the threaded or tapped holes, these gages should have plain cylindrical holes representing, respectively, the external diameter of the maximum and minimum screw. These templet gages are designed to admit at the maximum end all screws that are within the limits, and to reject all screws that are larger, while screws smaller than the minimum end of the templet gage are thus shown to be less in diameter than is specified by the minimum limit.

For the convenience of users of machine screws and taps, Table IV. gives the diameters of drills for holes to be tapped for the standard machine screws. The diameter given for each hole to be tapped allows for a practical clearance at the root of the thread of the screw, and will not impose undue strain upon the tap in service.

*Extract from the revised report of the Committee on Standard Proportions for Machine Screws, accepted by the society at its Indianapolis meeting, May 28-31, 1907. The committee consisted of Mr. Wilfred Lewis, ch., and Messrs. Charles C. Tyler, Horace K. Jones, John Riddell, George R. Stetson and George M. Bond.

TABLE I.—STANDARD SIZES, NUMBER OF THREADS, AND LIMITING DIAMETERS OF SCREWS AND TAPS.

American Society of Mechanical Engineers Standard Proportions for Small Machine Screws.

Basic and Maximum Screw Diameters. External diam. and No. thds. per in.	Pitch diameter	Root diameter	Minimum Screw Diameters. External diameter	Pitch diameter	Root diameter	Minimum Tap Diameters. External diameter	Pitch diameter	Root diameter	Maximum Tap Diameters. External diameter	Pitch diameter	Root diameter
.060—80	.0519	.0438	.0572	.0505	.0411	.0609	.0528	.0447	.0632	.0538	.0466
.073—72	.064	.0550	.070	.0625	.052	.074	.063	.056	.0766	.066	.058
.086—64	.0759	.0657	.0828	.0743	.0624	.0871	.0769	.0668	.0898	.078	.0689
.099—56	.0874	.0758	.0955	.0857	.0721	.1002	.0886	.077	.1033	.0897	.0793
.112—48	.0985	.0839	.1082	.0966	.0808	.1133	.0997	.086	.1168	.101	.0877
.125—44	.1102	.0955	.1210	.1082	.0910	.1263	.1116	.097	.1301	.1129	.0995
.138—40	.1218	.1055	.1338	.1197	.1007	.1394	.1232	.1069	.1435	.1298	.1097
.151—36	.1330	.1149	.1466	.1308	.1097	.1525	.1345	.1164	.1569	.1359	.1193
.164—36	.146	.1279	.1596	.1438	.1227	.1655	.1474	.1294	.170	.1489	.1323
.177—32	.1567	.1364	.1723	.1544	.1307	.1786	.1583	.138	.1835	.1598	.1411
.190—30	.1684	.1467	.1852	.166	.1407	.1916	.170	.1483	.1968	.1716	.1515
.216—28	.1928	.1696	.2111	.1903	.1633	.2176	.1944	.1712	.2232	.1961	.1745
.242—24	.2149	.1879	.2368	.2123	.1807	.2438	.2166	.1896	.250	.2184	.1931
.268—22	.2385	.209	.2626	.2358	.2013	.2698	.2403	.2108	.2765	.2421	.2144
.294—20	.2615	.229	.2884	.2587	.2208	.2959	.2634	.2309	.3031	.2653	.2346
.320—20	.2875	.255	.3144	.2847	.2468	.3219	.2894	.2569	.3291	.2913	.2606
.346—18	.3089	.2738	.3402	.3070	.2649	.3479	.3119	.2758	.3539	.3137	.2796
.372—16	.3314	.2908	.366	.3284	.281	.374	.3334	.2928	.3828	.3364	.2968
.398—16	.3574	.3168	.392	.3544	.307	.400	.3594	.3188	.4088	.3614	.3228
.424—14	.3776	.3312	.4178	.3745	.3204	.4261	.3797	.3333	.4359	.3818	.3374
.450—14	.4036	.3572	.4438	.4005	.3464	.4521	.4056	.3593	.4619	.4078	.3634

TABLE II.—FORMULAS FOR STANDA[illegible] FOR MACHINE SCREWS AND TA[illegible]

Basic Standard Thread, U. S. [illegible]

SCREWS:

Max. Ext. Diam. = Basic Ext. Diam.
Max. Pitch Diam. = Basic Pitch Diam.
Max. Root Diam. = Basic Root Diam.

Min. ext. Diam. = Basic Ext. Diam. — [illegible]

Min. Pitch Diam. = Basic Pitch Diam. — [illegible]

Min. Root Diam. = Bas. Rt. Diam. — $\left[\frac{0.108}{\text{T.P.I.}}\right]$

TAPS:

Max. Ext. Diam. = Basic Ext. Diam. + [illegible]

Max. Pitch Diam. = Basic Pitch Diam. + [illegible]

Max. Root Diam. = Basic Root Diam. + [illegible]

Min. Ext. Diam. = Basic Ext. Diam. + [illegible]

Min. Pitch Diam. = Basic Pitch Diam. + [illegible]

Min. Root Diam. = Basic Root Diam. + [illegible]

Note.—T.P.I. = Threads per inch.

TABLE III.—DOUBLE END TEMPLET THREAD GAGES FOR INSPECTION OF SCREWS.

Formula: Thickness = $1.443 \sqrt{\text{Pitch}}$

Threads per inch.	Thickness.	Threads per inch.	Thickness.
80	0.161	30	0.263
72	0.170	28	0.273
64	0.180	24	0.295
56	0.193	22	0.308
48	0.208	20	0.323
44	0.217	18	0.341
40	0.228	16	0.361
36	0.240	14	0.385
32	0.255		

TABLE IV.—TAP DRILL DIAMETERS FOR STANDARD MACHINE SCREWS.

Screw Diam. and Threads, per inch.	Tap Drill, Diam.	Screw Diam. and Threads, per inch.	Tap Drill, Diam.
.060—80	.0465	.216—28	.173
.073—72	.0595	.242—24	.1935
.086—64	.070	.268—22	.213
.099—56	.0785	.294—20	.234
.112—48	.089	.320—20	.261
.125—44	.0995	.346—18	.281
.138—40	.110	.372—16	.295
.151—36	.120	.398—16	.323
.164—36	.136	.424—14	.339
.177—32	.1405	.450—14	.368
.190—30	.152		

RESULTS OF USE OF DIFFERENT VALVE GEARS ON LOCOMOTIVES.*

As this association was favored at its last convention with an admirable mathematical analysis of various forms of valve gear in use on locomotives, it is evident from the wording of the subject assigned to this committee that it is desired to present the practical considerations governing present-day locomotive engineering in regard to choice and design of valve gears, and the results obtained in general practice and use. The subject is, perhaps, the least understood of all the detail mechanism of the locomotive; and while most railroad and drawing offices can produce men competent to lay out and design the ordinary type of motion, yet the builders are very generally called upon to furnish the design, subject possibly to a specification that allows and expects the builder to use his best judgment in regard to these important details.

That this confidence is not misplaced is to be seen daily in the fine performance of engines the country over, in all classes of service—fast and slow, passenger and freight, work and switching.

It seems hardly worth while to spend much time going back to the early history of locomotive valve motion. While, no doubt, much could be said about the different kinds of valve motions that have been used in the past, the committee feels that it should take up only the points that will be most profitable to the association. The problems of our day are based on different conditions and have to do with vast increases of weight, power and speed over and above those of only a few years past.

Without going into detail, therefore, regarding the "hook" and others of the older motions which now no longer survive, it can be stated that by far the greater number of engines in this country are equipped with what is commonly termed the Stephenson link motion. This is probably true also, but in a less degree, in the

*From Report of Committee of American Ry. Master Mechanics' Ass'n.; presented at convention, Atlantic City, June 12-14.

British lines; but on the continent of Europe it is estimated that the Walschaert motion leads all others.

The Stephenson link motion has held its own in this country, almost without consideration being given to other types, until within very recent years. The types and weights of engines employed lent themselves to convenient use of the link motion, which has many desirable and valuable features to commend it.

The time came, however, when it became expedient to make changes for some of the following reasons: Some types of engines have so many wheels, or are so closely grouped, that it is a difficult matter for engine men to get under them except when over a pit. This contributes to neglect, lack of prompt adjustments for wear, lack of proper inspection, and a more rapid deterioration. With the increase in size and weight, the dimensions of eccentrics required for large axles are excessive and their peripheral speed is so great as to make maintenance and lubrication of the eccentrics and straps expensive and troublesome. In the long list of materials for this purpose appear plain cast iron; cast iron, babbitt-lined; bronze; cast steel, brass-lined; gun metal, etc.

By the abolition of eccentrics and straps a long list of engine failures is eliminated; expense for maintenance and lubrication is reduced; room is gained for better cross-bracing and strengthening of frames, and for adding to convenience through men not being required to go under engines to the same extent.

On heavy engines the weight of all moving parts of a link motion, from the eccentric straps through to the valves, is so great as to contribute to accident and rapid wear; so that an equally efficient valve motion with lighter parts and greater accessibility is in demand for heavy power.

For many reasons we cannot lower the standard of efficiency as set by the Stephenson link motion. Economy in the use of coal and water are more necessary than a reduction in weight and wear of valve motion parts. No railway manager will sanction the use of a device, no matter how beautifully simple it may be, if his fuel costs are thereby increased.

Fortunately, we are able to obtain a valve motion having the desirable features of lighter parts and accessibility without a loss of efficiency in the Walschaert motion, which has come into extensive use the last few years.

The following tables of weights are given for engines said to be identical in everything except the valve motion, and for a 22-inch consolidation engine, built by the Baldwin Locomotive Works.

	Complete Moving and Structural Parts.		Moving Parts Only.	
	Stephenson.	Walschaert.	Stephenson.	Walschaert.
Crossheads	676	746	676	746
Guide bearer	814	1,116	....	....
Guides	1,712	1,712	....	....
Eccentrics	600	....	600	....
Crank arms	....	250	....	250
Eccentric straps ..	1,100	....	1,100	....
Main crank pins..	520	516	520	516
Links	238	418	238	413
Reverse shaft	325	655	325	655
Rockers and boxes	618	730	618	730
Rocker rods and hangers	169	....	169	....
Link bearing	....	234	....	....
Eccentric rods	184	264	184	264
Valve rods	220	546	220	546
Valve yokes	154	140	154	140
Valve rod guide ..	24	28	....	....
Complete set	7,354	8,321	4,804	4,265

These figures indicate that while the engine with the Walschaert motion weighed 1,000 pounds more than the other one, on account of the motion, yet the weight of the moving parts was less. The "American Engineer and Railroad Journal" of June, 1905, published some figures showing saving of weight by the use of the Walschaert motion on engines of the Lake Shore & Michigan Southern Ry., as follows: 1,283 pounds on a consolidation, 1,215 pounds and 1,745 pounds respectively on two classes of Prairie type engines. These figures indicate a larger saving than the foregoing example; but it is possible that, as these were early developments, they may not be representative of present successful practice.

It is a fact that similar valve motion parts on engines abroad are very much lighter than we dare use in our own practice. It seems fair to conclude, therefore, that we may yet look for improvement in this respect.

The matter of lead has received much attention, particularly with link motion; but, as a matter of fact, the measured full gear lead is only used possibly for a few turns of the wheels in starting the engine, and when running notches are in use the lead is entirely different—the amount being dependent upon various conditions. As the running notch leads for best results are within narrow limits, it is apparent that the full gear leads vary within a wide range. The amount of full gear lead is therefore of little importance in the operation of the engine if the running notch lead is right. If these premises are correct, then there can be no argument against the constant lead characteristics of the Walschaert motion, provided the lead is of the proper amount for the running notches.

The practical operation of the Walschaert motion is best shown by the testimony of roads using it in considerable numbers. At a recent meeting of motive power officers and locomotive builders, held to discuss the results of the use of Walschaert motion engines—the roads represented having about 1,000 such engines—it was the unanimous opinion that the Walschaert motion was equally well adapted to fast and slow passenger and freight service; that equivalent economies in fuel and water were obtained; that no reductions of tonnage ratings were necessary; that expenses of maintenance and repairs were reduced; that inspection and repairs were facilitated; that construction advantages in the way of frame cross-bracing, etc., were increased; that valve adjustments made are maintained and engines kept square much longer on account of the motion being more direct, rigid and positive for the passage of the valve-driving stresses: and that convenience of enginemen, inspectors and shop men is promoted by the accessibility of the motion.

The discussion thus far has been with reference to the valve-actuating mechanism proper, as ordinarily used on locomotives for operating the usual types of slide or piston valves. There are available for the use of railroads some patented forms of valve motion or systems of steam distribution which are claimed to obtain economies superior to those of the types already mentioned.

The Young valve gear has been applied to engines with Stephenson link motion, and later a Walschaert motion having some detail modifications from the regular design has been proposed. The motion acts upon a wrist plate which has connections to two semi-rotary valves, and the effect of the combination produces valve events remarkable on account of absence of preadmission, small amount of lead, quick port opening, large exhaust area and fine equalization of the events. It is claimed that, due to these features, fine performance and superior economies are obtained which more than compensate for the cost of maintenance of additional parts required.

For the past six years the Allfree-Hubbell designs for improving steam distribution have been under test, and the designers have made such changes from time to time as seemed best. The first design or "geared system," as the designers called it, has been superseded by what is known as their "compression system," some of which have been in service for several months. This design is supposed to embrace the economic features of the original design with some additions and, as it now stands, it attempts to produce the following results: Late release, late compression, low clearance, balanced compression, reduced cylinder radiation, quick admission and quick release.

In the later design an auxiliary valve has been introduced for the control of compression alone, and allows the main valves to be made and set for a desired release with the Stephenson link, Walschaert, or any other motion, all the changes being made in the cylinders and valve alone. This device has been under test on several roads, and from an average of several reports it seems to give about 6% reduction in fuel consumption and 5 or 6% increase in train load, and is able to maintain the same or a little more speed than engines of the same size and ordinary design, except as to cylinders. There is also a lighter drain on the boiler for steam, but we are unable to express the amount in figures.

In making a study of this system for causes of the results claimed, we find a very late compression, which, according to the argument of the designers, means that the negative working pressure is acting at a time when it produces the least effect on the crank pin. In other words, when the crank pin is very near the center, from this point alone an increased load is possible not so much from an increased working pressure as from a reduced negative work. In view of the above argument, any given load could be handled with a smaller amount of steam, which means a smaller amount of coal and therefore brings the handling of greater load within the possibilities of the boiler. In addition to this, the reduced clearance is claimed to be responsible for a considerable steam economy.

C. A. Seley (Chairman),
R. Quayle,
L. H. Turner,
J. H. Manning,
Committee.

CULEBRA CUT excavation in May amounted to 690,365 cu. yds., while at Gatun 70,360 cu. yds. was dug. The May total is less than for March and April, due partly to rainy weather and partly to the strike of the steam shovel engineers; but it exceeds the record of any previous month.

A UNIFORM SYSTEM OF MUNICIPAL ACCOUNTing for the State of Iowa went into effect on April 1 of this year. The legislative act providing for the system calls for local reports annually, and also for a State report, the latter to contain copies of the local reports. The uniform system of accounts is to be prescribed.

THE USE OF ALLOY STEELS IN AUTOMOBILES.*

By ELWOOD HAYNES.†

Since the first attempt to build automobiles, early in the 90s, experimenters have had difficulty in getting materials suitable for the purpose. Steel of high tensile strength was employed but the results were ever the same. Lower carbon steels were tried, but they lasted only a few weeks or months and then broke short off. Swedish iron did not break, but when the first hard bump was encountered it took a set and the wabbling rear wheels indicated what had happened. Finally a steel of moderately low carbon was introduced which gave only fair results, and if the car was driven for any length of time over rough roads, this also crystallized and broke off.

NICKEL STEEL.—In 1899 a nickel steel axle was introduced into a machine by Messrs. Haynes & Apperson, and the car made successfully a trip from Kokomo, Ind., to New York, a distance of about 1,000 miles, without serious breakage of any kind. This axle was made by the Bethlehem Steel Co., of Bethlehem, Pa., and so far as is now known, was the first material of this kind ever introduced into an automobile. Nickel steel was used in the axles of cars of this construction for about five years, and not a single case of breakage occurred during that period. Not only was this steel found to be practically free from crystallization, but it possessed a very high elastic limit—about 70,000 or 80,000 lbs. per sq. in.—and a tensile strength of over 100,000 lbs. per sq. in., with an elongation of about 15 or 20%.

Soon afterward nickel steel was introduced into the construction of driving chains and showed great superiority over those formerly made of ordinary steel. When the sliding gears were first used on the automobile for the purpose of changing the gear ratio between the motor and rear axle, trouble again asserted itself in breakage. In vain were gears made of the best form of tool steel; the ends of the teeth would break off when an attempt was made to throw them suddenly into engagement by means of the shifting levers. Trouble of a very serious nature resulted from this, as pieces of the broken teeth would get into the other gears, thus causing them to break, and sometimes the entire train of gears would be almost ground to pieces on account of the breakage first of one gear and then of another.

NICKEL CHROME STEEL.—Machinery steel, case hardened, was tried, and while this gave better results, it was by no means satisfactory. The injury and breakage of sliding gears were taken as a matter of course, and almost every person possessing a car equipped with these gears expected sooner or later to make a number of replacements.

It was finally discovered that an alloy consisting of iron, nickel, and chromium possessed most remarkable properties. Not only could the steel be hardened by heating to redness and quenching in oil, but it could be given a considerable amount of toughness at the same time by drawing the temper somewhat after the first hardening. If the steel was properly made and afterward properly treated it was found to be almost impossible to break one of the teeth in a 6-pitch gear by means of a heavy hammer. So successful were these gears that they rendered it possible to run an entire season sometimes without the breakage or serious injury of a single tooth. Front axles, steering knuckles, and other important parts requiring high elasticity were made of this steel in certain cars with very good results.

The greatest difficulty encountered by the manufacturer was in the working of the steel, which was found to be extremely difficult. Fortunately, about the time of its early introduction a tool steel was discovered which possessed most remarkable properties. This steel consists mainly of an alloy of tungsten, chromium, and iron, with but a very small percent of carbon. One of the most remarkable properties of this steel is its capability of becoming very hard and tough when quenched from a glowing white heat by dipping into a bath of oil. This method of tempering would ruin ordinary tool steel, but it produces in the tungsten chromium steel a substance which is capable of cutting the hardest forms of nickel steel and nickel chromium steel with comparative ease. While this alloy tool steel is not used in the actual construction of the automobile, it is referred to because its use is essential in the turning and machining of the high strength alloy steel.

It has been found that the manufacturing and working of nickel chrome steel requires great care, as there seems to be some tendency toward segregation when the steel is in the process of making, which gives rise to hard and soft spots in the finished metal. If an attempt is made to manufacture gears from material of this character, it will be found that some of the teeth are extremely hard while others are just about the right hardness. On the other hand, even if the steel is of uniform composition and texture throughout, it will not stand very great variation of temperature without danger of injury, since it is very sensitive to heat treatment.

*A paper presented at the Indianapolis meeting of the American Society of Mechanical Engineers, May 28-31, 1907.

†Kokomo, Ind.

When properly made and properly treated, however, it is perhaps the most resistant substance yet produced so far as the resisting shocks and blows is concerned. This renders it especially suitable for sliding gears which are subjected to the destructive action due to the striking of the teeth when forced into mesh while in motion.

The following may be taken as a test of high quality nickel chrome steel made by the Krupp Co., of Essen, Germany. It will be noted that much depends upon the treatment of the steel:

DIMENSIONS OF TEST BARS, 5.91 INS. LONG AND 0.59-IN. DIA.

	Normal	Slightly hardened	Greater deg. of hardness.
Elastic limit, lbs. per sq. in.	86,909	148,072	193,589
Tensile strength, lbs. per sq. in.	111,943	155,326	221,325
Elongation, percent	14.5	9.1	7.7
Contraction, percent	64.0	55.6	46.2

It will be noted from the above tests also that under the hardening treatment the tensile strength rises rapidly, and the same may be said of the elastic limit, rising as it does from 86,909 lbs. to 148,072 lbs. when slightly hardened, while the tensile strength rises from 111,943 to 155,326. With a greater degree of hardness the elastic limit reaches 193,589 and the tensile strength 221,325. It will be also noted that the elongation gradually diminishes from 14.5% in the normal steel to 7.7% in the more highly hardened specimen. The contraction of area also falls from 64% in the normal to 46.2% in the highly hardened steel. The contraction of area does not suffer so much as the elongation. The comparatively small loss in contraction of area is a good sign, since it indicates that the texture of the steel has been well preserved under treatment.

Plain nickel steel containing a very small percent of carbon is also a good safe material for automobile work. The following may be taken as an example of a mild low-carbon nickel steel: Elastic limit, 65,146; tensile strength, 81,561; elongation, 23.9%; contraction of area, 71%. It will be observed from this that while the elastic limit is quite low as compared with the nickel chrome steel, it is high as compared with ordinary carbon steel and that the elongation and contraction of area are very high indeed, indicating a very safe material for almost any construction. This material not only possesses these excellent properties, but resists dynamic stress remarkably well—in fact, if the dynamic stresses are not too close to the elastic limit of the steel, it will preserve its strength and quality for an indefinite time. The following tests indicate the quality of this material as compared with carbon steel, under combined torsion and vibration: Carbon steel, 15,000 vibrations; nickel steel, 34,000,000 vibrations (not broken).

VANADIUM STEEL.—Besides the steels already mentioned, there is another which is now attracting considerable attention; namely, that produced by adding a small quantity of vanadium to a nickel steel or chrome steel. Since vanadium has until recently been classed among the very rare elements, it may perhaps be in place to mention a few of its properties; it is prepared from the chloride V Cl_3, which is reduced by means of a current of hydrogen gas, the chloride being heated while the reduction is taking place. Simple as this process may seem, it is one of the most difficult known to chemists, and it usually requires three or four days to prepare a fraction of an ounce of the metal by this process. Until quite recently this element and its compounds, owing to their rarity, were very expensive, but we are now assured by the American Vanadium Company that a sulphide of vanadium has been discovered in an immense quantity in the Andes mountains of South America, and that they are now prepared to furnish the metal in the form of a ferro alloy known as ferro-vanadium in any quantity desired. This ferro-vanadium contains about 20% of the latter metal and is readily incorporated with the iron or steel during the melting, either in the open-hearth or crucible process. Mr. J. Kent Smith, who has given the subject of vanadium steel much attention, advocates the open-hearth process as preferable to the crucible process for the making of this steel.

This steel possesses most remarkable qualities, notwithstanding the small quantity of vanadium which it contains. One of these is the closeness with which its elastic limit approximates its tensile strength, and since the former quality is the one in which the greatest dependence is placed, this is a very desirable characteristic. Sharp contraction of area is also a characteristic of this steel, which together with the silky fracture it usually presents, is a strong indication of the splendid quality of this material. Moreover, the fracture is nearly always of this quality, even though the steel has been highly tempered.

It is a rather remarkable fact that the vanadium alone or with carbon does not give much character to the iron or steel, but when a third element is introduced, such as nickel or chromium, the characteristics of the steel are changed for the better. Whether the vanadium acts as an essential element in the composition of the steel or principally as a purifier is not fully known; it has been found, however, that a certain amount of the vanadium introduced (about ¼%) must remain in the steel in order to give it its characteristic properties. Vanadium, however, has a strong affinity for nitrogen as well as for oxygen, and it may be that it acts as a purifier of the steel by combining with minute quantities of nitrogen gas, which might otherwise be occluded in the steel and thus interfere with its compactness and strength.

It will readily be seen that high elastic limit, strong contraction of area and splendid silky fracture, together with the large number of vibrations which the steel endures under dynamic stress, most strongly recommend this steel as almost ideal for many parts of the motor car. The writer has made some experiments in forging it, and found that it works well under the hammer, though it must not be allowed to become too cold or it will resist pounding to a remarkable degree. It is not readily injured under the forging hammer, provided due care be taken not to heat it too rapidly. Another valuable property of the steel is the fact that it machines more readily than nickel chrome steel—in fact, more readily than plain nickel steel.

BRONZE.—The use of bronzes in the motor car must necessarily be restricted to parts requiring low rigidity, and usually also moderate strength. While it must be admitted that samples of bronzes can be made that approach closely to fairly good grades of steel in tensile strength, elastic limit, and contraction of area, it must also be remembered that the modulus of rigidity of iron and steel is about 28,000,000 lbs., for example, while that of bronze is only about 15,000,000 lbs. This means that a bar of bronze of a given size and form under given conditions will deflect nearly twice as much under the same load as a similar bar of iron or steel. In most parts of the car this feature is objectionable, since changes of alinement are likely to occur unless the parts which are made of this material are especially well designed.

Notwithstanding the above objection the readiness with which bronze lends itself to the production of castings of various parts, and its freedom from crystallization under dynamic stress has led to its introduction into many of the minor parts of the motorcar, such as small hand levers, carbureters, tubing, crank cases, gear cases, etc. In general, it may be said that it is suitable for the small levers such as those used for controlling the sparking mechanism, carbureter, etc. Another use for this metal is in bearings, although these require a decidedly different composition from that used for levers, crank cases, and like parts.

The parts requiring strength are usually made from nickel bronze, phosphor bronze, manganese bronze, or aluminum bronze, while the bearing bronzes are composed usually of lead, tin, and copper in various proportions. Under this latter head come also the so-called babbit metals which vary greatly in their composition, some of them being composed of lead, copper, tin, and antimony; others of lead, tin, zinc, and antimony, and still others of lead, tin, and antimony. It is not the purpose of the writer to discuss the merits of these various bearing metals, since a number of very good ones can be readily obtained on the market.

COPPER.—Beside the above alloys, pure copper is used to a considerable extent in the construction of radiators, gasolene tanks, etc. It is well adapted for the construction of radiators, since it can easily be soldered, is one of the best conductors of heat, and is readily formed into almost any shape on account of its malleability, ductility, and comparative softness.

ALUMINUM.—Aluminum is now used very largely in automobile construction, and it is a significant fact that it was first introduced into the automobile in America, though the French used it to some extent quite early for a few minor parts of their machines. Pure aluminum is used only for a few special purposes, and even then to a limited extent—most notably for tubing and radiators. It is quite well adapted for the latter purposes in many respects, but the comparative difficulty experienced in soldering it is somewhat of a drawback. On the other hand, when alloyed with copper or some other metal giving it increased hardness and elasticity, it is well adapted for various purposes such as seats, gear cases, crank cases, dashes, and various other parts of the car. Its extreme lightness, together with the ease with which it may be machined and the facility with which it may be cast, renders it very useful for many parts of the machine.

An alloy of zinc and aluminum seems to have considerable rigidity and elasticity, as well as quite high tensile strength. It is also cheaper than the aluminum copper alloy, but experiments made by the writer indicate that this alloy is not safe if subjected to repeated vibrations, since it seems to fatigue quite rapidly and sooner or later breaks off short. For example, a ½-inch square bar made of an alloy of aluminum and zinc withstood only about 15,000 vibrations before breaking, while an alloy of copper and aluminum withstood 1,600,000 vibrations of the same amplitude and frequency without breaking or showing any signs of injury except a very slight set. Aluminum also forms a very light alloy with magnesium, which, however, is too expensive for ordinary use and is somewhat difficult to handle in quantity. A number of other alloys of al[illegible] been prepared, and to some extent used [illegible] construction—the most notable perhaps o[illegible] alloy of tungsten and aluminum, which [illegible] to a considerable extent abroad, but is not [illegible] can cars so far as the writer is aware.

From the foregoing it may be said that [illegible] substances have proved suitable for the v[illegible] the automobile:

For rear live axles, nickel steel contain[illegible] cent. to 5 per cent. nickel and less than [illegible] carbon.

For front axles, steering knuckles, pro[illegible] shafts, etc., vanadium steel.

For sliding gears, nickel chrome ste[illegible] hardened throughout, or mild nickel steel case harden[illegible]

For crank shafts, nickel steel or vanadium [illegible]el.

For frames, low-carbon open-hearth steel [illegible] nickel steel or nickel chrome steel.

For nearly all other parts of the car, s[illegible] as hand levers, tubing, etc., a good open-hearth s[illegible] of comparatively low carbon—say 0.40% or under—[illegible] of suitable quality, since there is no advantage gain[illegible] by using high class steels for these purposes for the [illegible]son that the rigidity of these parts is of prime imp[illegible]ance, and in order to make them sufficiently rigid, the[illegible] must be made much more than sufficiently strong; therefore, since all steels are practically equal in rigidity one steel is, broadly speaking, as good as another for these parts.

The use of bronze should be restricted largely to minor parts; the reducing gear wheels, small levers, etc., can be made of phosphor bronze, while the bearings should be made of some good composition bronze—an alloy of copper, lead, tin and zinc answers well for this purpose, but the main bearings for the engine, such as the crankshaft, crank pins, etc., should be made of a special bearing metal, which is very firm and at the same time will not injure the crankshaft in case the lubrication becomes deficient. The crank case of the motor, the gear case and other similar parts may well be made of aluminum, since it is light, strong, and easily cast into the proper shape. Steel would answer for the above parts if it could be conveniently worked into the proper form.

It will be noticed from the foregoing that the most progressive automobile builders have spared neither pains nor expense in obtaining the very best materials that can be produced, because in order to obtain the highest results in automobile construction, it is necessary that material of superior quality shall be used for certain parts of the machine. Perhaps there is no form of construction that taxes the ingenuity of its builders more severely than the building of a good automobile. Take for example one of the high-powered touring cars carrying from five to seven persons and equipped with a motor of 50 HP. Now consider that this motor is sometimes geared down to such an extent that its direct torque is multiplied ten or twelve fold on the rear axle; consider further that the driver of the machine is often entirely inexperienced, and to a large extent ignorant of the strength of the material and the use of power, and it will be realized that the chances for trouble when driving an automobile are certainly very great. Now add to the stresses and possible abuses from the foregoing the severe jolting and jarring of the rough roads in America and some idea may be formed of the severe ordeal through which an automobile must pass during a season's run. It has been the general experience of builders that the more ignorant the owner of the machine the greater his complaint. On the other hand, those who are versed in mechanical matters and who know the sizes of parts generally used for heavy stress, often marvel at the strength and endurance of the modern automobile. Factors of safety must be reduced to a minimum in nearly every part of the machine or excessive weight is sure to occur. Many high class machines weigh less than 70 lbs. to the horsepower, passengers included. Of course it is not expected that the motor shall be used constantly at anything near its maximum horsepower—one-tenth of its brake horsepower is enough for almost any automobile motor when in daily use; high power is simply intended to meet emergencies, but the material throughout the machine must be strong enough to withstand any stress momentarily applied.

The following table gives approximately the strength of various materials used in automobile construction:

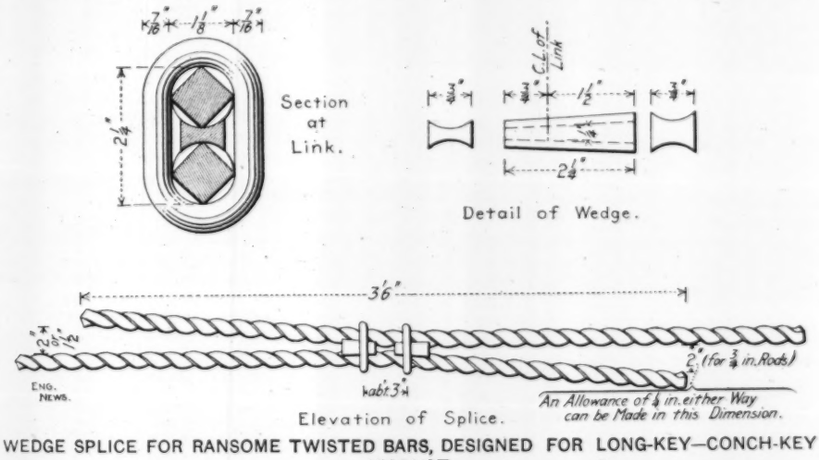
TABLE 2.—STRENGTH OF AUTOMOBILE MATERIALS.

	Modulus of rigidity, lbs. per sq. in. (million.)	Elastic limit, lbs. per sq. in.	Tensile strength, lbs. per sq. in.
Aluminum alloys	8 to 11	10 to 15,000	20 to 30,000
Phosphor bronze	12 to 14	20,000	30,000
Manganese bronze	15	35,000	50,000
Aluminum bronze	15	50,000	75,000
Wrought iron	28	30,000	40,000
Mild open hearth steel	28	40,000	60,000
Tool steel	29	80,000	110,000
Nickel steel	28	80,000	110,000
Nickel chrome steel	30	160,000	180,000
Vanadium steel treated	30	220,000	228,000

All of the above materials stand well under dynamic stress with the exception of the tool steel, which should not be used for this purpose.

A WEDGE SPLICE FOR RANSOME TWISTED REINFORCING RODS.

Perhaps the majority of cases of reinforced-concrete work involve reinforcing members of greater length than can conveniently be made by a single piece. Such members must be spliced to transmit tensile stress, usually by some means capable of developing approximately the full strength of the member spliced. This is not a simple problem, since such splices must be cheap, simple and securely applied, and preferably not such as to require special preparation of the ends of the members to be spliced, nor such as to make careful fitting of lengths necessary. The requirements suggested have brought two means of splicing into specially wide use: 1)wiring the members together by a soft tie-wire, to make a lap joint capable of transmitting tension by the friction between the bars; 2) using no external splice whatever, simply lapping the bars past each other and relying on the adhesive bond of the surrounding concrete to take the stress from either bar and transmit it to the other. It cannot be said that either method is ideally satisfactory, and experimental data to guide in their application are scanty or absent. A special splice



WEDGE SPLICE FOR RANSOME TWISTED BARS, DESIGNED FOR LONG-KEY—CONCH-KEY VIADUCT.

designed for an extensive reinforced-concrete arch construction therefore engages interest.

The accompanying sketch shows the splice completely. The work for which it was devised uses only twisted rods, but it would seem that a splice of similar construction is equally applicable to plain rods. The splice comprises two oval rings or links slipped over the lapped portion of the bars to be spliced, and drawn up each by a wedge driven between the bars. The wedges face in opposed directions, so as to counteract any tendency for the joint to work loose. The dimensions given in the sketch are those of a splice for ¾-in. rods. Specifications accompanying the design call for links of "a good quality of soft steel," not less in cross-sectional area than indicated; the links may be made of round steel, welded, or (when drop-forged from solid) of other cross-section. The wedges are required to have the small end project not more than ¾-in. through the link when driven home, and to have full-length bearing on the rods. It will be noted that no taper for the faces of the wedge is stated, the idea being to have the manufacturer adjust the taper to give the spread of bars shown by the assembly sketch.

This splice was designed for the Long-Key Conch-Key Viaduct* of the Florida East Coast Railway's Key West extension, of which Mr. J. A. Meredith is Constructing Engineer and Mr. R. W. Carter Bridge Engineer. The design is due to the latter, we are informed. The viaduct in question consists of 180 arches of 25-ft. radius, generally of 50-ft. clear span. Its reinforcement comprises inner and outer arch rods, and horizontal and vertical rods, and the splice shown is employed for rods in all these locations. Two sizes of rod, ¾-in. and ⅝-in., are used in the work. Over 100,000 splices in the aggregate are required.

*See Engineering News of Oct. 19, 1905, p. 407, and May 9, 1907, p. 504.

THE WORK OF THE OHIO STATE BOARD OF HEALTH ON WATER SUPPLY AND SEWAGE DISPOSAL.

By R. WINTHROP PRATT.*

The old principle of common law which entitles all riparian owners to the use of a stream in a reasonably pure state, has afforded, in the past, a means whereby any individual, damaged by a polluted stream, could receive redress in court. The generally unrestrained contamination of streams, under the conditions of to-day, however, clearly points to the necessity not only for specific statutory provision against stream pollution, but also for supervision by some state or central authority whose duty it is to investigate all matters relating to stream pollution and to see that sewage and other polluting substances are not allowed to enter in an unpurified state any stream or lake where a water supply would be endangered, or where offensive conditions would result. By such arrangement much unnecessary litigation is avoided, and there are protected large numbers of persons, as well as municipalities, who, because of ignorance in sanitary matters, or because of the fear of becoming engaged in lawsuits, would fail to protect themselves. Through administrative control by the state, instead of adjustment through the courts alone, the future condition of our streams and water supplies can be given much more weight; so that with the growth of the country polluted streams will decrease rather than increase in number.

State supervision does not mean, in its broadest sense, the policing of drainage areas, and the more or less irregular enforcement of laws regardless of the local conditions, but it means, as in the case of the Massachusetts State Board of Health, the pioneer in such work, an intelligent and extended investigation, with experimental studies into all problems of water supply and sewage disposal. By this procedure a large fund of valuable information is collected, which places a board of health or other supervising body in a most favorable position to advise local officials in these matters. Thus an educational work is accomplished which will surely be effective in producing among the people a desire for pure water supplies and proper sanitation, and this desire will have a favorable effect upon the actions of State legislatures.

It is more essential, therefore, that a State board have such funds and assistance that it can properly keep in touch with all local conditions within its jurisdiction than that the statute books be loaded with stringent laws with nobody to enforce them intelligently.

On account of its lack of stringent laws, Ohio has not been included by Mr. Goodell† with those States which are given credit for having been most active in protecting their water supplies. It may be said, however, that Ohio, through its State Board of Health, has used to good advantage the laws which were available, and has endeavored to create through educational work among the people of the State a sentiment in favor of pure streams and water supplies.

The Ohio State Board of Health was created by the Legislature in 1886. The board was given the usual general powers regarding the control of epidemics and infectious diseases. It was also given advisory powers regarding public water supplies and sewerage, but no absolute authority over these.

The board is composed of seven members, one being appointed by the Governor each year. The members elect the secretary for a term of three years. Dr. C. O. Probst, Secretary of the American Public Health Association, has been the secretary and executive officer of the board for twenty years, and great credit is due him for his intelligent management of its affairs.

In 1893, at the time of the cholera epidemic at Hamburg, Germany, when some cholera cases were being imported into this country, the Ohio Legislature realized the importance of protecting public water supplies and therefore increased the authority of the State Board of Health along these lines. The present law, as passed in 1893, reads as follows:

> It (the State Board of Health) shall respond promptly when called upon by the State or local governments and municipal or township boards of health to investigate and report upon the water supply, sewerage, disposal of excreta, heating, plumbing, or ventilation of any place or public building; and no city, village, corporation or person shall introduce a public water supply or system of sewerage, or change or extend any public water supply or outlet of any system of sewerage now in use, unless the proposed source of such water supply or outlet for such sewerage system shall have been submitted to and received the approval of the State Board of Health.

Since 1893, therefore, it has been necessary that all plans for new projects for public water supplies or sewerage be approved by the board. In regard to works in existence previous to 1893, the board has no jurisdiction except to investigate and point out to local officials any conditions which need improvement. This lack of control over existing works is at the present time a weak point in the sanitary laws of the State. It is expected, however, that the present Legislature, at its next session, will strengthen the existing law.

In 1898 legislation was enacted authorizing the State Board of Health to establish and maintain a laboratory for the chemical and bacteriological examination of public water supplies and of sewage effluents; in addition, pathological work was provided for. The board was directed to examine and report annually upon the condition of public water supplies. About this time the board also established an engineering department for the purpose of making careful investigations of the proposed water supply and sewerage projects which came before it for consideration, as well as for studying the conditions of existing works.

During the years 1897 and 1902, inclusive, the board, through its engineering department and its laboratory, and with the aid of other temporary expert assistance, made a detailed study of the drainage areas of all the principal rivers in the State. One or two drainage areas were taken up each season. These studies included an investigation of all sources of pollution from cities and villages, as well as from factories. All sewerage systems and water-works were examined in detail, and the population using such works was determined. Chemical analyses of the rivers themselves were made at regular intervals, and the pollution of the water, in many instances, was thereby conclusively demonstrated. The results of these investigations, including maps and statistical information, will be found in the annual reports of the State Board of Health. These reports afford a very comprehensive view of Ohio conditions as regards stream pollution.

Supplementary to the above work, stream gaging stations were established on certain rivers, and these were later maintained for several years by the U. S. Geological Survey, under the im-

*Chief Engineer Ohio State Board of Health, Columbus, Ohio.

†In Water Supply and Irrigation Paper No. 152 of the U. S. Geological Survey, entitled, "A Review of the Laws Forbidding Pollution of Inland Waters in the United States."

mediate direction of the engineer of the State Board of Health. Daily gage readings and records of discharge, covering periods of from six months to three years, of some fifteen of the rivers of Ohio are now available. These have been of great service in studying sewerage problems and also in other work.

During 1905 the board, acting co-operatively with the Hydro-Economic Division of the U. S. Geological Survey, made a detailed study of the disposal of certain industrial wastes which had long been sources of complaint. Much valuable and practical information was gained in regard to the purification of dairy refuse, woolen mill waste, acid iron waste from tube works and the refuse from distilleries. The work on this last was especially interesting, as a method was developed whereby the valuable ingredients in the refuse could be reclaimed at a very substantial profit to the distiller.* The owners of the distillery at Lynchburg, O., instead of spending money, as formerly, to defend themselves against lawsuits for stream pollution, now have an income from the sale of their treated refuse.

In 1906, on account of the increased responsibilities of the board, due to the many important projects for water supply and sewerage which were submitted to it for approval, the Legislature made a special appropriation to enable it to increase its engineering and laboratory forces sufficiently to make a detailed examination of the construction, methods of operation and efficiency of all existing water and sewage purification works in the State.

At the present time, therefore, the Ohio State Board of Health is giving a great deal of attention to the problems of water supply and sewage disposal. The routine work of the engineering department consists in making reports upon the proposed schemes which are continually being submitted, in responding to the calls of local officials for advice, in inspecting the construction of new work in order to see that it is being carried out in accordance with the approved plans and in making, as far as possible, regular examinations of existing water supplies.

The special work consists of a series of detailed inspections of the water purification and the sewage purification works in operation in this State. One of the assistant engineers devotes his entire time to the water purification works and another to the sewage purification works. Each visit usually occupies two or three days, during which, in case of water purification works, samples of raw and of filtered water are collected for analysis at frequent intervals; and observations of the rates of filtration, coagulants used, and other features, are carefully made. The bacterial samples are all plated, and most of the other analytical work is done, at the plant. This avoids the undesirable feature of shipping the samples by express. A corresponding procedure is followed in the inspection of sewage plants.

This special water and sewage work has proved of very great value, not only on account of the information which the board has gained for use in acting upon future plans, but also because the work has served generally to educate and interest local officials in their own plants. In a few cases the plants have been materially changed, on the strength of the board's recommendations, and their efficiency greatly increased. At four of the larger sewage plants the operators have been trained to make each day simple chemical tests and incubation tests of the purity of the effluents. At both the sewage and water plants, in the majority of instances, the superintendents are furnishing the board with daily records of the principal features of operation.

The importance of water filtration to the people of Ohio is very great. The difficulty of obtaining abundant ground water supplies makes it necessary for all of our large towns and cities to depend upon surface waters, which in nearly every case require filtration either because of sewage contamination or because of turpidity, or for both reasons. At present in Ohio water filtration plants are in operation in 14 municipalities, having an aggregate population of 175,000 people. Within a year plants at Cincinnati, Columbus and Toledo will be completed, and then the above figures will be increased to over a million people. Ohio will then lead all other States, excepting possibly Pennsylvania, in the percentage of her population served with filtrated water.

The constantly decreasing dry weather flow of our streams, and the building up of communities along their banks, have made the problem of sewage disposal an important one. At present there are 35 sewage purification plants in operation in the State—19 municipal and 16 institutional. Plans for some 30 more have been approved (usually with conditions) by the State Board of Health, and some of these are now in process of construction. By far the largest plant in the State is the one now being built at Columbus. When this is in use the total population in Ohio tributary to sewage purification works will be nearly 300,000.

One of the most important problems with which the board has to deal is the question of the degree to which a given sewage must be purified. There are many factors which affect this question. Standards of purity applicable to all cases have proven impossible. In cases where it is not necessary to protect a water supply, or dairy, or market garden interests, there is obviously no need of purification greater than that obtained by removing most of the suspended solid matter and rendering the liquid, together with the small amount of solid matter which may remain in it, non-putrescible; that is, the purified sewage must be fairly clear and must not putrefy and become offensive on standing indefinitely at as high a temperature as 98° F.

Where the stream receiving the effluent is used for public water supply purposes the problem takes on an economic aspect, and the question arises: ought a municipality to be required to increase the cost of its sewage works, say two or three times, and transform its sewage into a potable water for the purpose of protecting a water supply many miles down-stream, when the stream through its numerous tributaries undoubtedly receives, in any case, a greater or less amount of miscellaneous pollution before reaching the water supply intake? Ought not all dangerous organisms which may come from the sewage works or from elsewhere on the drainage area be removed by water filtration works operated by the municipality or company owning the water-works? The last question is especially significant if water filtration works are already in operation.

It is necessary to weigh carefully the conditions governing each case in order to arrive at a just decision. There are natural agencies of purification in every stream; but, so far as the removal of dangerous bacteria is concerned, the value of these agencies is very uncertain, on account of constant fluctuation in the velocity and volume of stream flow, changes in temperature, changes in chemical and physical composition of the water and other factors. According to the official statement of the British River Pollution Commission, in 1868:

> There is no river in the United Kingdom large enough to secure the oxidation and destruction of any sewage which may be discharged into it, even at its source.

Subsequent experience in England, as well as in this country, has, to a large extent, borne out the significance of this statement. Swift running rivers, contrary to the usually accepted theory, are more dangerous than sluggish streams in regard to conveying pollution, for with the latter pathogenic organisms are longer subjected to "unfavorable environment." Dilution is an important factor in purifying a stream, but cannot be counted upon to remove all harmful matter of sewage origin.

All things considered, it seems unjust to allow a community to discharge into a stream used as a water supply any disease-producing organisms, the destruction of which can be effected without unreasonable difficulty, provided, of course, that the sewage works are located at such a distance from the water supply that the natural agencies above discussed cannot be depended upon. In other words, the water filtration works should not be given an extra burden to perform. This is especially true under the usual American conditions, where the care of water filters is often intrusted to careless or incompetent management. Water-works officials, whether they operate a filtration plant or not, have a right to expect that as much pollution as possible will be kept out of the sources of supply at every point, and that the water will be as pure as is practicable to keep it before arriving at the intake. Innocence is better than repentance.

To purify sewage to the high degree above discussed means considerable added expense. Either sand filters of ample area must be installed for the final treatment of the sewage effluent, or else there must be provided some means for sterilizing the effluent from works

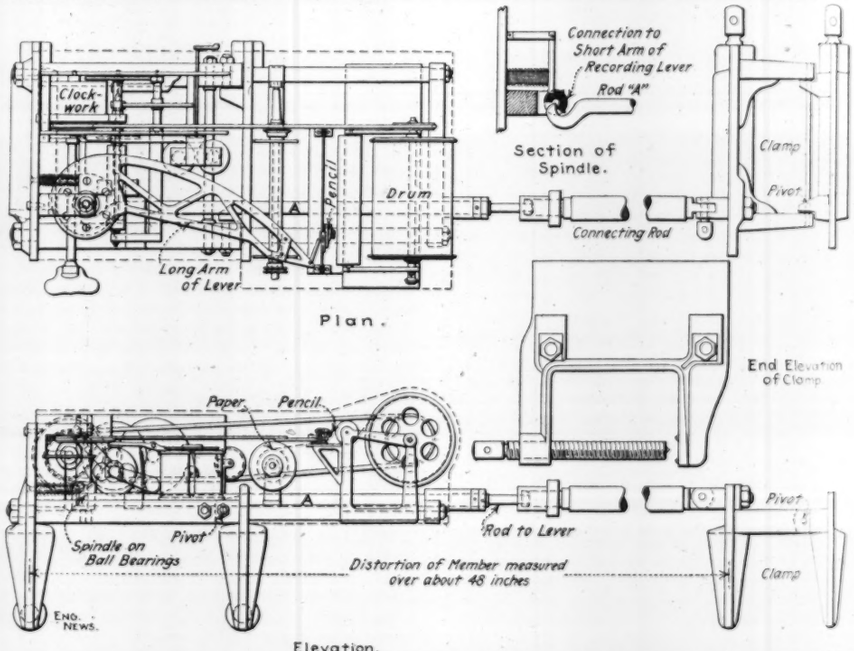


FIG. 1. EXTENSOMETER FOR MEASURING AND RECORDING DEFORMATIONS IN BRIDGE MEMBERS DUE TO IMPACT STRESS.
Prof. F. E. Turneaure, University of Wisconsin, Madison, Wis., Designer.

* Water Supply & Irrigation Paper No. 179 of the U. S. Geological Survey, "Prevention of Stream Pollution by Distillery Refuse," by Herman Stabler.

which purify the sewage to the non-putrescible state only.

The Ohio State Board of Health has required sand filters to be added to proposed works in several instances where the effluent was to be discharged into a stream used as a water supply. The practicability and efficiency of the sterilizing process under modren conditions, however, is one of the most recent developments in the art of sewage purification, and it is not yet definitely settled whether this method will be practicable under all conditions. It is reported to have been used in England at several places with good results. Chlorine, or its compounds, seems to have afforded the best and most economical results. This substance can be produced electrolytically from salt water.

By way of cooperation in working out this problem, the Bureau of Plant Industry, U. S. Department of Agriculture, has for the last eight months placed two bacteriologists at the service of the State Board of Health. Under the immediate direction of the board these men have made thorough tests of the treatment of effluents from different sewage purification plants. The tests have included sulphate of copper and chloride of lime or bleaching powder, which last, when decomposed, produces chlorine.

One of the most important series of tests has been made at Marion, O.,* where the effluent from the sewage works is discharged into the Scioto River, 45 miles above the Columbus water supply intake. It is believed from the information recently gained in these experiments that a sewage effluent can be freed from pathogenic organisms without undue difficulty or expense. This process will, apparently, afford great protection to water supplies in the future, especially at times of epidemics.

The complete report upon the special investigation of the board into water and sewage purification, including the sterilization of sewage effluents and the softening of water, will be published about a year hence.

THE TUBE TUNNELS now nearing completion under the North and East Rivers at New York City number 14 in all. Of these, four are the Hudson companies tunnels under the North River, of which two are completed and two have the tunneling proper just started. The Pennsylvania's two tunnels, also completed, under the North River raise the total tubes under that river to six. Under the East River are the Pennsylvania's four tunnels, the Belmont syndicate's two tunnels and the New York Rapid Transit system's two tunnels at the Battery. The total expenditure on these tunnel lines and approaches will probably exceed that on the Panama Canal.

*Sewage plant described in Engineering News, Feb. 22, 1906.

AN EXTENSOMETER FOR RECORDING DEFORMATIONS IN BRIDGE MEMBERS UNDER IMPACT STRESS.

An instrument for measuring and recording deformations of bridge members under stress has been devised and built by Prof. F. E. Turneaure, Assoc. M. Am. Soc. C. E., Dean of the College of Engineering at the University of Wisconsin, especially for investigating the effect of impact. Satisfactory trial experiments have already been made, and it is now intended to construct a number of instruments and to conduct a comprehensive series of experiments on different railways under the direction of the committee on iron and steel structures of the American Railway Engineering and Maintenance of Way Association.

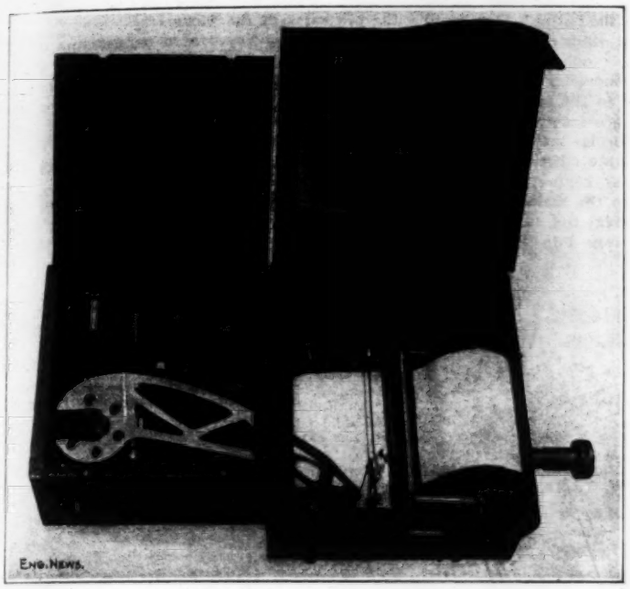


FIG. 2. RECORDING APPARATUS OF IMPACT TEST INSTRUMENT.

The instrument is an autographic extensometer for measuring the deformation of bridge members, the deformations being multiplied by a factor of 80 or 90 and recorded upon a strip of paper. Fig. 1 is a drawing of the complete apparatus, and Fig. 2 is a view of the recording instrument. This latter part of the apparatus is clamped to an eye-bar, angle or any projecting corner of a bridge member. Another clamp is attached to the same member at a distance of about 4 ft., or more if considered desirable. This latter clamp is connected to the recording apparatus by a light rod and a universal coupling. The clamps are of such width that they can be easily attached to the outstanding legs of angles, to eye-bars, or to any member not over 3 ins. in width. In Fig. 1, it will be seen that there are two clamps at the instrument; the one at the left is rigid, while the other is pivoted so as to allow of a slight rocking motion. This arrangement is for the purpose of fixing definitely the point from which distortions are measured. The clamp at the outer end of the connecting bar is a double-jaw clamp, having one jaw pivoted as above described.

In the interior of the apparatus is a rod running from the long connecting rod to the short end of a lever, on which it has a knife-edge bearing. The long end of the lever carries the pencil, which records its movements upon a traveling strip of paper driven by a train of clockwork. This lever is made of aluminum so as to be as light as possible, and is also very stiff. We are indebted to Mr. Turneaure for diagrams from some of the records, which are shown in Fig. 3. The character of the structure, the classes of locomotives, and the positions of the apparatus in these particular tests are shown in Fig. 4. In the accompanying table are given the stresses at various points indicated on the diagrams in Fig. 3.

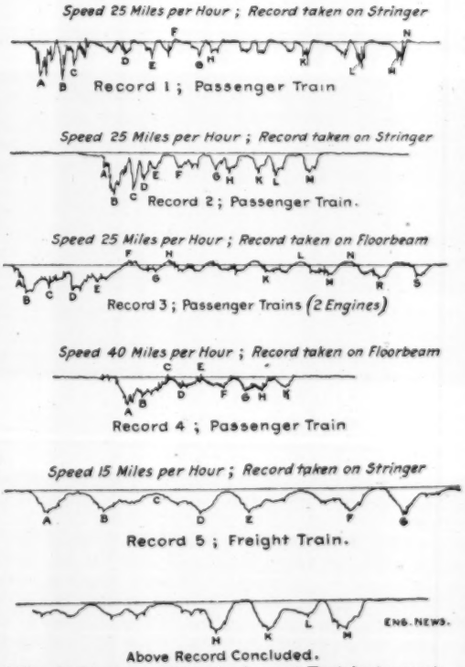

Speed 25 Miles per Hour ; Record taken on Stringer
Record 1 ; Passenger Train
Speed 25 Miles per Hour ; Record taken on Stringer
Record 2 ; Passenger Train.
Speed 25 Miles per Hour ; Record taken on Floorbeam
Record 3 ; Passenger Trains (2 Engines)
Speed 40 Miles per Hour ; Record taken on Floorbeam
Record 4 ; Passenger Train
Speed 15 Miles per Hour ; Record taken on Stringer
Record 5 ; Freight Train.
ENG. NEWS.
Above Record Concluded.

Fig. 3. Diagrams Taken by Impact Test Instrument.

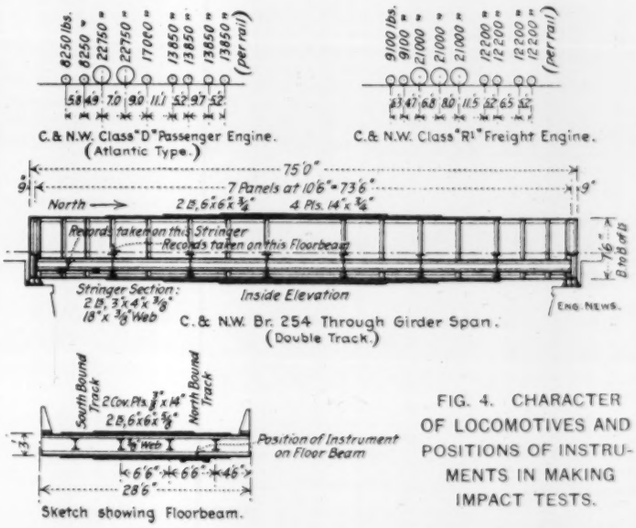


FIG. 4. CHARACTER OF LOCOMOTIVES AND POSITIONS OF INSTRUMENTS IN MAKING IMPACT TESTS.

TABLE OF STRESS AT POINTS ON CURVES REPRESENTING DEFORMATIONS OF BRIDGE MEMBERS.

Record.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Train	Pass.	Pass.	Pass.	Pass.	Freight.
Speed	25 m.p.h.	25 m.p.h.	25 m.p.h.	40 m.p.h.	15 m.p.h.
Member.	Stringer.	Stringer.	Floorbeam.	Floorbeam.	Stringer.
Stress (lbs. per sq. in.) in Records (Diagrams) Nos. 1 to 5.					
Point.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
A	—4,540	—1,900	—1,610	—3,390	—2,925
B	—4,875	—5,560	—3,610	—2,680	—3,120
C	—3,170	—4,830	—3,025	+ 497	— 498
D	—1,680	—3,500	—3,320	—1,560	—3,320
E	—2,190	—2,045	—2,140	+ 634	—3,410
F	+ 214	—1,950	+ 830	—1,560	—3,120
G	—2,040	—2,240	— 683	—1,855	— 390
H	—1,510	—2,630	+ 925	—1,855	—4,240
K	—1,805	—2,580	—1,170	—1,462	— 400
L	—2,585	—3,025	+ 497	.....	—1,950
M	—1,690	—2,540	—1,415	.....	—3,900
N	+ 342	.....	+ 438	.....	.....
R	.....	.....	—1,900	.....	.....
S	.....	.....	—1,660	.....	.....

— = Tension. + = Compression.

From the report of the discussion in regard to the Turneaure instrument and the impact tests at the annual convention of the American Railway Engineering and Maintenance of Way Association we take the following particulars:

Mr. Turneaure.—Experience with a similar apparatus in which the multiplication is much larger indicated that the features which need special attention in the design of such an instrument were as follows: 1. The multiplication must not be too great; 2. Very rigid parts; and 3. Very light parts, so that the inertia of the moving parts will be as small as possible. I think these ends have been accomplished to a greater extent in this apparatus than in the Frankel instrument, where the multiplication is something like 140 or 150. Some tentative

experiments with this apparatus indicate that it will do better work on short members, where the stress varies very rapidly. It has been tried on 10-ft. I-beam stringers, under speeds of 30 or 40 miles an hour, with quite satisfactory results. I am not sure that it would give such results on such short members under higher speeds, but on girders and members which receive their maximum load for a movement of train of 15 or 25 ft. and upward, I think the result will be satisfactory.

It is proposed in carrying out experiments of this sort to have 8 to 12 such instruments attached simultaneously to the different parts of the structure. They can be connected electrically so that the papers can be started in motion simultaneously. An experimental train would then be moved across the bridge at different rates of speed. It is not proposed to make calculations of what the stress should be, but to run a train at a slow speed, 10 or 15 miles an hour, and let that stress represent the static conditions. Then as the speed of the train is increased up to the maximum, a comparison of the diagrams would give the effect of speed pure and simple.

The relation between the measured stress and the calculated stress is a question that can be taken up independently of the question of impact, but the question of impact can be studied very rapidly provided we have an experimental train to be run over the bridge at any desired rate of speed. By having a number of instruments a pretty thorough test can be made on an ordinary bridge in a day's work, or at most in two days.

Mr. Snow (Boston & Maine Ry.).—With this instrument can you investigate the action of counterbalances on the driving wheels as they affect the rail?

Prof. Turneaure.—It might detect the variation in effect of counterbalancing on short-span girders of 15 to 25 ft. in length. In experiments made some 10 or 12 years ago with the Frankel apparatus it was thought that most of the impact effect, or a large part of it at least, was due to the fact that the locomotive wheels are not exactly counterbalanced, so far as the rotative effect is concerned. One of the very important points to determine would be the effect of different types of engines, particularly the relative effects of the balanced compounds and the ordinary locomotive, and probably the effect of the electrical locomotive where the rotating parts are more perfectly balanced.

Mr. Ewing (Phila. & Reading Ry.).—Will the machine also record the effect that flat spots on wheels have upon the structures? That is being brought to our attention more than anything else at this time, so far as damage to rails is concerned. The M. C. B. specifications have for years allowed 2.5 ins. on the flat spot, notwithstanding the fact we have increased the capacity of cars to a very great extent.

Prof. Turneaure.—That could be determined by having experimental trains and cars with wheels having flat spots. In the work that I referred to a moment ago, we found that very heavy vibrations were caused in bridges of 150-ft. span in the case of certain freight trains, under the cars as well as under the locomotives. Moving freight cars, if of certain length compared to stringer length, etc., were found to set up vibration where the speed was just right. That might have been due partly to flat wheels. We never found any serious vibrations under passenger cars, but did find very heavy vibration under freight cars. Anything that causes a modification of the impact, whether it is the ballasted floor or the steel floor, or in the details of the truss itself or in the locomotive or in the cars—anything, in fact, that affects the relation of static stress to dynamic effect is, of course, all comprised in these results, and they can be thoroughly studied only by varying one of these elements at a time.

THE PINEY BRANCH CONCRETE ARCH BRIDGE AT WASHINGTON D. C.

By W. J. DOUGLAS,* M. Am. Soc. C. E., and W. P. DARWIN,† Assoc. M. Am. Soc. C. E.

The design and specifications for the construction of the 125-ft. span concrete arch across Piney Branch on the line of 16th St. in Washington, D. C., have been treated in Engineering News in the issues of Nov. 16, 1905, and April 19, 1906. The portion of the bridge called for under the present appropriation has recently been completed and the construction presents some points of interest different from the ordinary in this kind of work.

The Piney Branch Bridge is a concrete viaduct, 272 ft. long, consisting principally of a main arch of 125 ft. span and 39 ft. rise, with the arch ring in the curve of a parabola. The present bridge is but 25 ft. wide and is offset from the center line of the street so that in future when a wider bridge is required a twin structure can be erected on the other side of the center line and the intervening space bridged with reinforced concrete beams. The floor system is all carried from the arch ring by means of reinforced-concrete columns and beams, the same system being also used in the abutment.

*Engineer of Bridges, District of Columbia.
†Assistant Engineer of Bridges, District of Columbia.

METHOD OF LAYING THE ARCH RING.—The method of building the arch ring is shown on Fig. 1. All concrete was placed in horizontal layers, top forms being used for blocks 2, 3, 5, 8, 10 and 12, but omitted in the rest. The alternate blocks were separated during construction by the steel struts shown on the drawing. These struts, which cost $425 for the entire bridge, were used instead of the usual timber because they could be left in place after concreting, thereby making the process of concreting much easier and also adding somewhat to the strength of the arch ring. Contrary to previous procedure on the Connecticut Avenue Bridge at Washington, which was built by the same office, and following European practice, the keying blocks 8-14 were all made smaller than the main blocks. In the Connecticut Avenue Bridge the maximum settlement of the falsework was 3 ins., 2½ ins. of which was due to the main blocks and ½-in. to the keying blocks. This latter settlement was enough to cause lipping in the soffit between abutting blocks. This is extremely undesirable from the esthetic standpoint. The keying blocks at Piney Branch, being much smaller than the main blocks, caused no measurable additional settlement. The soffit of the arch is quite smooth.

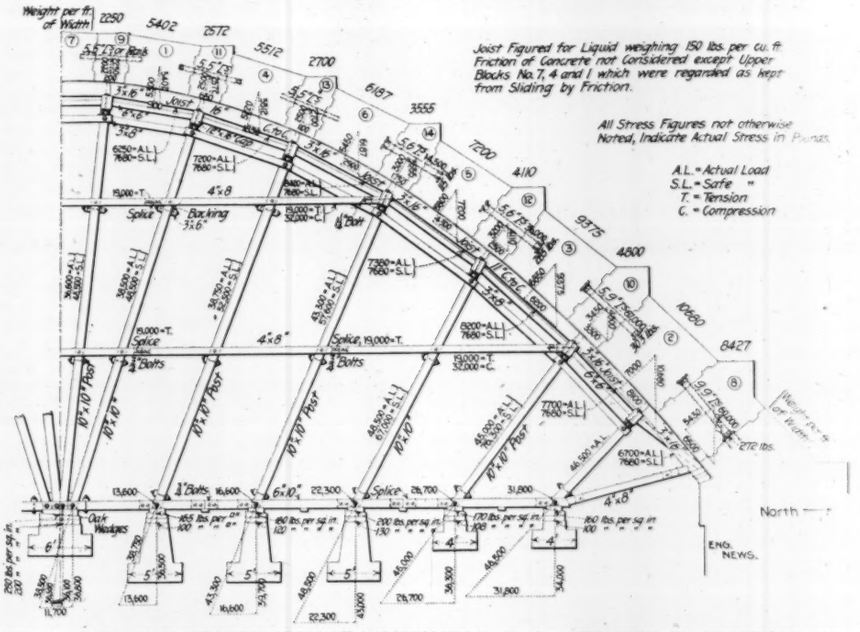


FIG. 1. THE PINEY BRANCH ARCH AT WASHINGTON, D. C. STRESSES IN CENTERING AND METHOD OF LAYING UP ARCH RING.

The concrete was mixed by a one-yard Smith mixer, delivered in buckets on narrow gage tracks alongside the bridge and lifted by derrick to position. All concrete was made of such consistency that the laborers sank ankle deep in it. It was placed in 9-in. courses and spaded to a neat finish against tongue-and-groove lagging, except for the unfinished surfaces, where rough boards were used.

CENTERING.—The centering is shown in Fig. 1. The article in our issue of April 19, 1906, gives a full description of this centering, together with an extremely novel method of erecting it. The stresses are indicated clearly in the drawing, and but few notes are necessary to bring out the design. The 6 × 6-in. struts which parallel the soffit of the arch were used as stiffeners, as were also the longitudinal 4 × 8-in. struts, but it is now a question in the minds of the designers whether or not both sets of these struts might have been omitted without injuring the center. The examination of the ends of these timbers and of the abutting timbers indicated that they were stressed very little. It is thought that the 3 × 8-in. ties, ju... 6 × 6-in. struts, which were necessa... tion purposes, were about all that ... sary at the tops of the bents. The ... were adequate for the purpose inten... that two of them, adjacent to the cen... tions, sheared off when they were used ... up for the jacks that drove out ... wedges, during the process of strikin... ters. It would have been better to ha... these pedestals with steel rods in orde... the pressures of the jacks.

The arch was keyed at a temperatur... 80° F. and was struck at a temperatu... 40° F. This fall in the temperature ... shortening of the arch ring, and as ... was very stiff, small air cracks form... spring line, that is, the arch crept up ... tering. There were only two temperatu... and they were very small, and hardly ... to the eye, and when the center was str... cracks entirely disappeared and canno... detected under the most minute examin...

ARCH DEFLECTION.—As noted in previous articles, gage rods were placed at regular intervals along the arch ring and readings were taken after each block was placed to determine the amount of settlement of the ring. The results of these readings are shown in Fig. 2. The deformation of the center as plotted therein was the average of three lines of gage rods, one line being on the axis of the bridge and the other two lines at the face. The maximum settlement of the gages on the face was ¼ in. less than that of the axis of the bridge. In the design of the center, it will be noted that by making the distances between the exterior posts of the bents somewhat less than the total width of the bridge, it is arranged so as to bring practically the same load on each post of a bent regardless of whether or not the post is at the face or in the center. This is a question of vital moment in the construction of heavy concrete arches, because if the exterior posts have a less pressure than those nearer the axis of the bridge the result will be that transverse sections of the arch soffit will not be straight lines but curved ones, convex downward, and this unequal settlement of the posts may result in a longitudinal crack forming at approximately the axis of the bridge.

In the deformation diagram, Diagram A, immediately under the arch ring, gives the total deformations; estimated and measured, in their true relation to the curve of the arch. Diagram B gives the effect of each load separately; the

vertical scale is greatly magnified. It will be noted that block No. 1 caused the centering to rise over the haunches, due to the arch action of the joists, which were continuous from the crown to haunches. The small keying blocks apparently did not affect the centering, as it was assumed in the computation, and this difference makes the measured deformation less than the estimated. The computation for the deformation was made by assuming the stresses to act in the directions shown on Fig. 1 and to pass

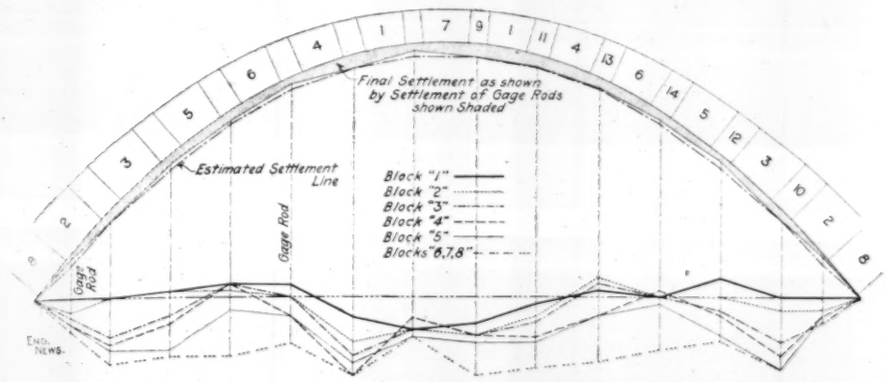


FIG. 2. PINEY BRANCH BRIDGE. SETTLEMENT OF CENTERING DUE TO LOADING OF ARCH RING. COMPARISON BETWEEN ESTIMATED AND MEASURED DEFORMATION.

into the centering, giving stresses marked on each member. The deformation at any point is due to the elastic compression in all members leading to that point in addition to a certain assumed amount of closure in each wood joint. The measurements were all taken before the ring was keyed and do not take into account any rise or fall due to temperature or shrinkage. This entire system of gage rods cost $50, not counting the cost in salaries of men reading them, and the engineers in charge think that the information derived as to the effect of arch loads on centering was worth many times the cost of the device.

STRIKING CENTERS.—The centers were lowered by means of jacks applied against the wedges on top of the temporary concrete piers under the main centering posts. A 20-ton jack was as a rule sufficient, but some of the wedges required a 30-ton jack and the large center wedges required two 30-ton jacks. All wedges had been greased, but it is thought that the grease did not facilitate the striking. The maximum pressure on each of the center wedges was

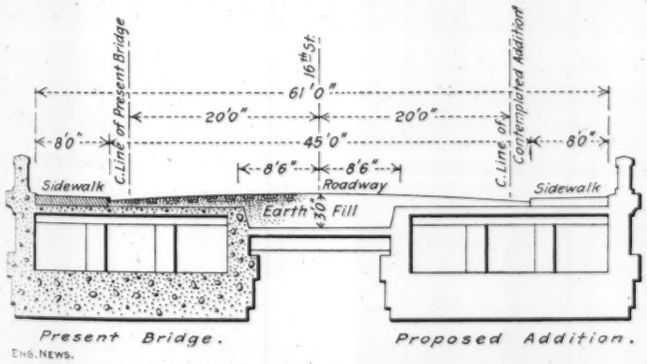


FIG. 3. CROSS-SECTION OF CROWN OF PINEY BRANCH BRIDGE AS IT IS TO BE WHEN COMPLETED.

(The bridge as built at present only comprises the left ring.)

144,000 lbs., approximately, or 280 lbs. per sq. in.; the maximum pressure on the other wedges was 39,000 lbs., or 180 lbs. per sq. in. The coefficient of friction was about 0.4.

After the center had been lowered about five inches by means of the wedges, the demolition was begun. First the wedges of the bent next to the spring line were jacked out of the longitudinal side blocks and this bent was lowered by block and tackle to the ground, and was then taken apart. When this bent was lowered it carried the joist and lagging down with it, that is, that portion of the joist and lagging which was attached to this bent. Incidentally it might be said that the demolition would have been somewhat easier if the distance between the top of the foundations and the bottom of the posts had been about a foot more than it was, in which case, after the removal of the wedges, there would have been sufficient room between the lagging and the soffit of the arch to economically remove the lagging and joists without the injury resulting from their falling to the ground when the bents were lowered, as just described for the first bent. The remaining bents were lowered to the ground as described for the first bent.

GENERAL DETAILS.—As previously stated, the bridge has been built for only about one-third of its width. Fig. 3 shows the cross-section of the structure, as it will be when completed.

The bridge trimmings are spaded work, and the plain spandrel and abutment areas are pointed or rather picked, using an ordinary pick for this purpose in order to bring out the concrete texture of these areas. The trimmings have a yellow tone which was arrived at by using bank sand in this concrete, and the spandrel and abutment areas have a bluish cast which was attained by using stone dust in this concrete in lieu of sand. Briquettes were made of the blue stone dust and the result indicated greater tensile strength than was attained for the sand. It is thought that the abutments are particularly economical on account of the narrowness in height of the bridge and on account of the fact that these abutments must be widened at some future date. The ordinary type of U abutment would have required an abutment of almost solid concrete to withstand the outward thrust of the earth. On single track railway bridges of considerable height where concrete is used, this type of abutment should be particularly economical.

The bridge was designed in the office of the Engineer of Bridges of the District of Columbia, Mr. W. J. Douglas, M. Am. Soc. C. E., under the direction of Col. John Biddle, M. Am. Soc. C. E., Engineer Commissioner, and Capt. J. J. Morrow, M. Am. Soc. C. E., Assistant Engineer Commissioner. Mr. W. P. Darwin, Assoc. M. Am. Soc. C. E. was Engineer-in-charge. The contractor was the Penn Bridge Company, with Mr. John Meigs, Engineer-in-charge for the company. The costs of construction were:

Contract price	$42,731
Extra work	5,000
Engineering	3,000
Inspection	1,500
Total	$52,231
Cost per sq. ft. of area	$7.00

RECOMMENDATIONS AS TO PRACTICE IN LOCOMOTIVE LUBRICATION.*

The committee divided the subject as follows:

(1) With reference to high steam pressures and superheated steam. (2) How far may we economize in lubrication, both internal and external? (3) The consideration of standard fittings for lubricators. (4) The consideration of sight-feed lubricators versus pumps for internal lubrication.

First: With reference to high steam pressures and superheated steam.

In 1906 the committee reported that for locomotives with steam pressures as high as 225 lbs., or those using superheated steam the temperature of which is as high as 600° F., the ordinary valve oil had been found by experience to be quite suitable; the problem is one of delivering the oil in proper quantities to the places needing it; the committee believes the latter to be possible with the modern sight-feed lubricators.

Second: How far may we economize in lubrication, both internal and external?

(a) Internal lubrication should not be stinted; that an engine may perform its work without undue wear or heating. Dry valves and cylinders mean rapid wear of the surfaces of contact and excessive trouble with the valve motion parts.

With the slide-valve locomotive there is not so much danger, as the jar of the reverse lever attracts attention to the fact that oil is needed and the engineman will see that the valves are properly lubricated. With piston-valve locomotives the internal lubrication may be much below the required amount without any indication from the reverse lever, and the cause of the trouble may have been operating a long time before being discovered; in other words, the engineer on a slide-valve engine, even on a small allowance of oil, is more apt to keep the valves supplied with enough oil to prevent hard service to the machine, while with piston-valve engines he is not so able to tell that the valves need oil, and no one knows that the parts have been running too dry until trouble comes through heated bearings and worn or broken parts.

With this in mind the committee feels that for internal lubrication 70 miles per pint for large freight locomotives, and 80 miles per pint for large passenger locomotives, seem to be the amounts needed to lubricate properly. The amount to each class depends upon the speed at which the locomotive is running; in bad water districts the oil allowance should be increased about 25%.

(b) External lubrication. The use of grease on crank pins and driving axles seems to offer the best solution of how to decrease the cost and at the same time secure the best results; the committee report of last year stated, as the result of experience with 203 locomotives, that grease as a lubricant gave results about as follows:

Reduced engine failures due to heated journals and pins; reduced cost of lubrication; reduced cost of labor incident to inspection, cleaning and renewal of lubrication packing; reduced delays incident to oiling; reduced cut journals incident to oil lubrication; possibly produced a slight increase in machine friction.

Third: Consideration of standard fittings for locomotives.

The 1906 convention referred the committee's recommendations, as shown in the 1906 Proceedings, page 379, Fig. 1, page 380, Figs. 2, 3, 4 and 5, and page 381, Fig. 6, to letter ballot, and they are now standards of the association.

Fourth: Sight-feed lubricators vs. pumps for internal lubrication.

The committee is of the opinion that a well-designed sight-feed lubricator, having pipe connections suitably arranged so as to deliver the oil in the most direct way to the parts needing it, will under present conditions do the work properly. On superheated locomotives it is, we believe, generally conceded that there should be one pipe from the lubricator leading direct to the cylinders and attached to separate plugs near the center, so that the oil fed from the lubricator, for the cylinder, may be properly distributed. The question of location of plugs in the steam chest is one point on which we find considerable difference of opinion; one member of the committee, who has had considerable experience with superheated steam, favors putting the steam chest plugs at the end of the valve chest in preference to attaching the oil pipe to the center of the chest and letting the oil be carried by the steam to the parts where needed; and the committee as a whole believes that the question of locating steam chest connections is one that can be left open and, therefore, do not care to make any recommendations.

D. R. MacBain, Chairman; S. M. P., Mich. Cent. R. R.
R. D. Smith, Mech. Exp., N. Y. C. Lines, Chicago.
R. F. Kilpatrick, S. M. P., D., L. & W. R. R.
C. Kyle, M. M., C. P. Ry.
W. O. Thompson, S. M. P., N. Y. C. & H. R. R. R.
Committee.

*Report of Committee at Convention of Ry. Master Mechanics' Ass'n, Atlantic City, June 12-15.

STREET RAILWAY TRACK AND PAVING AT FORT WAYNE, IND.

The Fort Wayne & Wabash Valley Traction Co., which operates about 150 miles of street and interurban electric railway, has adopted four standard types of track construction for paved streets, the different types to be used according to local conditions. In all cases the rails are of the tee-girder section, 5¾-ins. or 6 ins. high, with cement mortar (1 to 4) packed against the outer side of the rail webs. The details of construction are clearly shown in the cross sections, Fig. 1, prepared from drawings for which we are indebted to Mr. H. L. Weber, Chief Engineer.

Type A.—The rails are spiked to white oak ties laid upon a 5-in. bed of concrete, and having concrete filled in flush with the tops of the ties. Over this is a filling of 1¾-ins. of sand between the rails, while outside the rails is a bed of sand and cement for the rows of blocks laid between the rail head and the sheet asphalt pavement. Brick paving is used between the rails, with nose blocks to form the flangeways.

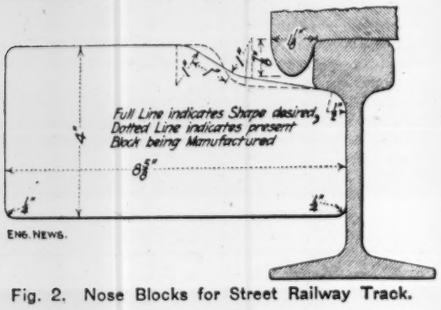


Fig. 2. Nose Blocks for Street Railway Track.

Type B.—Here the ties are laid on a 6-in. bed of broken stone, but in other respects the construction is similar to that of Type A. In both A and B, for street grades of less than 1%, the paving is crowned between the rails, but in Type C, for grades of over 1%, this part of the paving is practically flat.

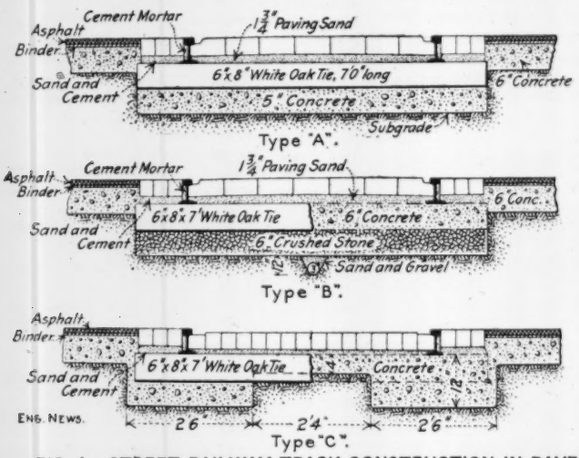
Type C.—In this design there is a concrete beam or longitudinal stringer, 30 ins. wide, under each rail, 6 ins. deep under the ties, with 4 ins. of concrete between the ties at the middle and only a thin bed of sand under the paving blocks. It will also be noted that instead of nose blocks flat blocks are laid against the rails, while the level of the paving is below that of the rail heads. In all these three types the wooden ties are spaced 3 ft., c. to c., except that under the rail joints they are 15 ins., c. to c.; these joints have 22-in. splice bars and four bolts.

TABLE I.—COST OF STREET RAILWAY TRACK.

	Type A.	Type B.	Type C.
Concrete, cu. yds.	0.215	0.088	0.204
Crushed stone, cu. yds.	...	0.128	...
Nose blocks	6.6	6.6	...
Paving blocks	24.0	24.0	30
Ties per 5¾-in. rail (30 ft. long)	10	14	10
Ties per 7-in. rail (30 ft. long)	8	14	8
Tile per 30-ft. rail	...	30 ft.	...

TABLE II.—CONCRETE POLES.

	Trolley Pole.	Transmission Pole.
Length, total	32 ft.	42 ft.
Height above ground	24 ft.	34 ft.
Concrete	22.5 cu. ft.	29 cu. ft.
Concrete	3164 lbs.	4060 lbs.
Steel	122 lbs.	Bars, 242 lbs. Steps, 21 lbs.
Weight, approximate	3300 lbs.	4400 lbs.
Cost (at gravel pit)	$7.50	$13



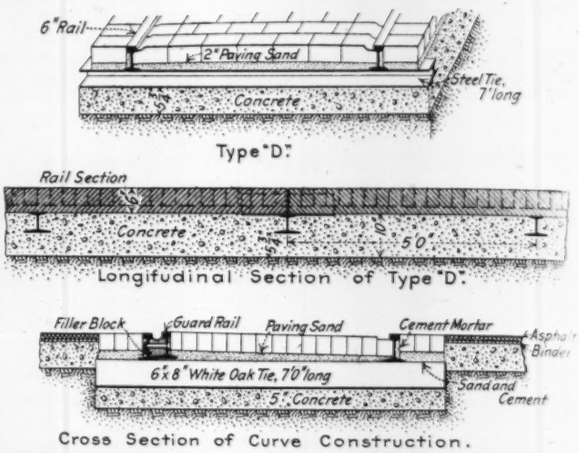


FIG. 1. STREET RAILWAY TRACK CONSTRUCTION IN PAVED STREETS; FORT WAYNE & WABASH VALLEY TRACTION CO. H. L. Weber, Chief Engineer.

Type D.—This differs from the others in that steel ties are used, spaced 5 ft. apart. These ties are of the Carnegie or Duquesne type, of I-beam section; 5 ins. deep, 4 ins. wide over the top flange and 6 ins. over the bottom flange, with ¼-in. web. They are 7 ft. long and weigh 14.5 lbs. per ft. The rails are secured by four flat clamps, with ¾-in. bolts passing through holes in the top flange of the tie. The bolts are oval, 25/32 x 1-1/16-ins., fitting oval necks on the bolts. Ties of this type, but of heavier section for steam railway work, were described in our issue of Aug. 24, 1905. A 2-in. bed of sand is laid over the concrete and ties to carry the brick paving (with nose blocks), and a row of header blocks is laid against the outside of each rail.

The bottom cross section in Fig. 1 represents the construction on curves where guard rails are used. The foundation is similar to that of Type A, while the paving is as in Type C. The concrete costs about $5 per cu. yd. in place. The brick paving costs from $1.85 per sq. yd. when no cars are operated to $2.25 per sq. yd. when cars are in operation. The cost includes the foundation of the pavement proper, but not the special concrete work below the bottom of the ties. The quantities per lin. ft. of track for the types using wooden ties are shown in Table I.

The flanges of the car wheels are 1⅛-ins. thick (at level of tread) and ⅞-in. deep (below tread). The flangeway of the pavement, however, allows for a depth of 1¼-ins., and will take the flanges of ordinary railway wheels. With this arrangement the electric railway company is enabled to haul over its lines in brick-paved streets the standard railway freight cars loaded with ballast and ties. The special work in future will also be made to accommodate the flanges of ordinary railway car wheels. The present and modified forms of the flangeway as made with nose blocks are shown in Fig. 2; these blocks were designed by Mr. Weber years ago when city engineer of Richmond, Ind.

CONCRETE TROLLEY POLES.

An interesting feature of the pole line construction of this city and interurban railway is the proposed use of concrete trolley poles and trans-mission-line poles. These were designed by Mr. Weber and the details are clearly shown in Fig. 3. They are to be made at the company's gravel pit, with a wet mixture of 1 cement, 3 sand, and 3 gravel or finely crushed stone; this has a ½-in. facing of cement and sand 1 to 3. Each post will have eight twisted steel bars, and the 42-ft. poles have steps and pin sockets. The weight and cost, etc., are shown in Table II.

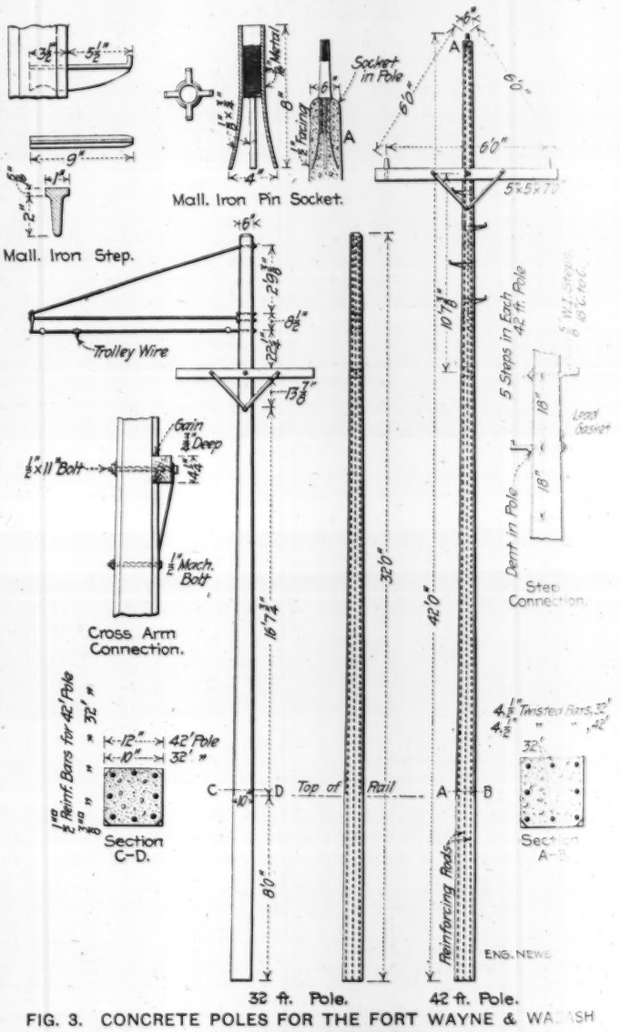


FIG. 3. CONCRETE POLES FOR THE FORT WAYNE & WABASH VALLEY TRACTION CO.

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Among the many almost unentered but nevertheless promising fields for engineers are those pertaining to state and local boards of health. At least one engineer is now included in the official staff of a half dozen state boards of health and more than one is to be found in Massachusetts, New York, Pennsylvania and Ohio. The Indiana board appointed an engineer but recently. Michigan has had one, in effect, if not officially, for many years. The Connecticut and (we understand) Illinois boards have engineer-members, as Massachusetts has had for many years; and if we remember rightly, so has North Carolina. The first state board of health provided with a chief engineer was Massachusetts, at least as early as 1890. The next board to create that office was Ohio. An outline of the engineering and allied work now being done by the Ohio board, written by its chief engineer, appears elsewhere in this issue. The Ohio work reviewed is connected with the broad subject of water pollution, its prevention and rectification. At times, in Ohio and elsewhere, such work expands so as to include the investigation of typhoid epidemics and reports on nuisances other than those affecting water. It is to be expected that other states will soon join those named in adding engineers to the official staffs of their state boards of health, and that in a number of states not one but many engineers will eventually be employed. Such will necessarily be the case whenever and wherever vigorous campaigns against water pollution and typhoid fever are undertaken. Many additions will also be made to the number of engineers now employed by local boards of health. Eventually it will be widely recognized that a well-trained sanitary engineer is far better equipped than a practicing physician for the position of local health officer, and that where medical health officers are employed, in places of considerable size, they should be aided by sanitary engineers.

The bulging and cracking of firebox sheets is one of the principal causes of trouble and expense in the item of locomotive boiler maintenance and repair work. The trouble is largely due to the inadequate allowance for the expansion and contraction of the side plates under the severe and varying conditions of temperature and stress to which they are subjected in service. The side plates are held at the ends by riveted connections to the tube and back sheets and are also riveted to the mud-ring; in addition, they are attached to the outer (and cooler) shell plates by staybolts spaced but a few inches apart. The temperature in the plates themselves varies at different parts, and owing to the staybolts and riveted seams the plate has no free movement. Flexible staybolts have done much to relieve the trouble.

Some experiments have also been made on an extensive scale with fireboxes having side plates so made as to give the metal free play in allowing for the irregular movements due to temperature conditions. About 1895 Mr. George F. Wilson, then Superintendent of Motive Power of the Chicago, Rock Island & Pacific Ry., introduced the use of cupped side sheets. The plates were pressed to form cups or depressions, concave to the fire, about 3 ins. diameter and ½-in. deep. Each staybolt was in the center of a "cup," so that its head was somewhat protected from the fire, while the elasticity due to the cupping was expected to aid the bolt and plate to move together in unison.

Some 30 locomotives (or more) were fitted with these firebox plates, and in 1897 Mr. Wilson stated that on engines thus equipped and in use for two years not a broken or leaky staybolt had occurred, while with the ordinary construction there was considerable trouble from leaky bolts and cracked plates. However, the results appear not to have been permanent, and Mr. T. S. Lloyd, General Superintendent of Motive Power, informs us that as the anticipated results were not obtained the use of these plates was discarded about five years ago. A somewhat similar practice was tried on the Chicago & Alton Ry. in 1899. In this case, however, the cups were between the staybolts, but we are informed by Mr. C. E. Fuller, Superintendent of Motive Power, that there was as much trouble from leaky staybolts, breaking of staybolts and cracking of sheets as on engines having the ordinary plain side sheets, and all the Chicago & Alton engines fitted with the cupped plates have by this time been given new side sheets or new fireboxes.

Corrugated side sheets are used in the fireboxes of a number of engines recently built by the American Locomotive Co. for the Chicago & Northwestern Ry. This railway has employed corrugated sheets for some time, and with sufficient success to lead to their more extended use. The corrugations are vertical, extending from a little distance below the center line of the boiler almost to the mud ring. The staybolts are placed in the concave corrugations, and are thus partly protected from the direct action of the fire. At the fire door, the back sheet is bent inward before being flanged outward to fit the flanged opening in the back boiler head, thus enlarging the water leg and making a flexible attachment which allows for expansion and contraction movements in the back sheet of the firebox.

A different and more recent type of firebox construction designed for the same purpose is described elsewhere in this issue. Under this system, each side sheet is formed of a series of plates not in contact at the seams, and connected by vertical U-shaped strips which allow ample play for the movements of different parts of the plates. Over 100 locomotives equipped with this style of firebox are now in service, and are reported as giving very satisfactory results in regard to increased durability and a very material decrease in the expense for repairs and renewals.

The steady and rapid increase in the size and weight of locomotives, for both freight and passenger service, and the consequent necessary increase in the weight of moving parts, such as valve actuating mechanism, has led locomotive designers and builders to cast about for a valve gear that will give as efficient service as the Stephenson link motion (which has been in well-nigh universal use on American locomotives since the railway began), but which will be free from some of the well-known defects of the Stephenson gear. Matters of accessibility for repair and inspection and of economy in space are also factors of importance.

In a paper presented by Mr. C. A. Seley, Mechanical Engineer of the Chicago, Rock Island & Pacific Ry., at the convention last week of the Railway Master Mechanics' Association (or, more properly specifying, the report of the committee on this subject of which Mr. Seley is chairman, and which he presented before the Association) the relative merits of the Stephenson and the newer valve gears were very thoroughly discussed. The Walschaert gear, which has been for many years in common use on European lines, has been ignored in this country until very recently, for no better reason, we are forced to believe, than the fact that it looked too complicated to commend itself to American railway officers, coupled possibly with the fact that nobody had any commercial interest in it, as a patentee or otherwise, to push its introduction.

It was not until the trouble with the huge eccentrics (necessary on large locomotives with Stephenson link-motion) passed the limit of endurance that American motive power officials awoke to the fact that the valve gear used so long and successfully in foreign countries might have some points of superiority worth their attention.

It is not without interest in this connection to recall the old-time controversies of thirty years ago over the relative merits of English and American locomotives. It was urged with much force that the moving parts on an American outside-connected engine were easy to get at for inspection, lubrication and repair, while on an English crank-axle engine with plate frames, it was well-nigh impossible for the engine runner to get at these important parts.

This was sound doctrine, we believe. Yet during all these years, American locomotive designers have left their valve gears inside, under the boiler, where a good deal of wriggling and crawling was necessary to get at them; oblivious of the fact that in their continued use of the Stephenson gear they were copying one of the very features of English locomotive design which they had themselves condemned.

The character and effect of impact stresses in railway bridge members and the provision that should be made for them in designing bridges, have been frequently discussed at meetings of engineering associations. The result of such discussions, however, as affecting practice in bridge design, has been very slight, for the reason that the discussion has been based almost entirely upon arbitrary assumptions and personal opinions. All impact formulas are purely empirical and there has as yet been very little experimental work in this field.

At the annual convention of the American Railway Engineering and Maintenance of Way Association in 1906, the Committee on Iron and Steel Structures presented general specifications for steel railway bridges in which a certain impact formula was included. In the discussion this was attacked on all sides as being unsatisfactory in itself, and out of place in view of the fact that the committee recommended the carrying out of impact tests. The matter was discussed at considerable length, and the expense and difficulties of carrying out such tests on a sufficiently comprehensive scale were pointed out. It was stated that very extensive experiments on impact were made a few years ago by Mr. J. E. Greiner, M. Am. Soc. C. E., on the Baltimore & Ohio R. R., but the instruments employed, as well as the records made by them, were all destroyed in the Baltimore fire of 1904. The committee was instructed to continue its investigations and to consider the problem of making experiments to determine the dynamic effect of live loads on bridges.

At the convention held in March, 1907, the committee reported that an instrument for measuring deformations in bridge members under stress had been perfected by Prof. Turneaure, of the University of Wisconsin, and that several satisfactory trials has been made. The committee awaited the action of the association in regard to procuring funds for prosecuting effective work in this direction, as it had been suggested that the surplus funds of the association

might be applied to such an important investigation.

It developed, however, that the funds could not thus be used, and the Board of Direction therefore applied to the railways for assistance. A number of railways have agreed to pay a share of the expenses, apportioned on a mileage basis, and we are informed that sufficient funds are now available for building the necessary instruments and carrying out the tests. The instrument devised by Prof. Turneaure, which is to be used in these tests, is described elsewhere in this issue.

The failure last week of the Milliken Bros. Co., owners of the new steel rolling mills on Staten Island, New York City, has excited world-wide interest in financial circles as an illustration of the extreme difficulty in raising capital for any large enterprise in the present state of the security market. It is understood that the enterprise was placed in a receiver's hands from this cause alone. Nevertheless, the question remains unanswered whether in times of business depression, when competition is sharp, and prices are cut to the lowest point, the plant could survive in competition with plants located nearer the centers of iron and steel production.

It is not difficult to see the controlling reasons which led the Millikens to embark in the production of steel. For many years the firm has held a leading position in the fabrication and erection of structural steel, particularly for the export trade. Year after year, in common with others engaged in similar work, it has experienced long delays in securing material, due partly to oversold mills and partly to the delays of transportation between the iron and steel mills and Eastern shops. With the change from wooden to fireproof construction, New York has become an enormous market for structural steel. Added to this are the huge demands at this port for export trade.

There is, therefore, good reason to believe that a rolling mill located within the limits of New York City itself could come into close touch with the purchasers of steel and could command a steady and profitable market for its product.

On the other hand, it is against all the precedents of recent years to locate a steel rolling mill east of Pennsylvania. Time was when New York, Massachusetts and Connecticut boasted a respectable production of iron and steel; but nearness to supplies of ore and coal long ago gave the coal producing states located further west or south unquestioned precedence in these lines.

Further, success in any large rolling mill enterprise under modern market conditions would appear to require the complete working of the material from the raw ore. Any plant depending on the purchase and remelting of pig iron, as the Staten Island plant has done, is under a heavy handicap. To be permanently successful, a blast furnace plant should be added to the Staten Island mills. If this were done, supplies of ore could probably be obtained from Cuba, as is done by the Sparrows Point plant of the Maryland Steel Co. Coal and coke would still have to come long distances, but water transportation from Norfolk and other Southern coal shipping ports is available.

There is, in addition, the possibility that by using the blast furnace gas in gas engines the plant might have a large surplus of power to dispose of, which in New York City would command very high prices.

THE POINT OF ECONOMY IN THE DESIGN OF REINFORCED-CONCRETE BEAMS.

The conditions of economy in reinforced-concrete design are not so well fixed but that theoretical study may be a useful assistance in determining them. A suggestive contribution to such theoretical study appeared in our columns a few months ago. The author, Mr. F. W. Hanna, pointed out that in some parts of the country—in the sparsely-settled western mountain regions, for example—the relation between the cost of steel and the cost of concrete is quite different from that which obtains in districts nearer the points of supply; and that this difference may make it cheaper to use less reinforcement than would otherwise be judged proper. Starting from this view, he developed a mathematical expression for finding the stress-ratio, and hence the percentage of reinforcement, which [illegible] the cheapest beam for resisting a given [illegible]. By substituting in this expression the [illegible] cost of steel per unit of volume to [illegible] concrete per unit of volume, the economical reinforcement in any given case may be found in numerical value.

Similar calculations, it appears, had been given some time previously (see letter of [illegible] P. Church, Feb. 28, 1907, p. 245, and several contributions to the discussion of reinforced concrete in "Transactions of the American Society of Civil Engineers," June, 1906, pp. 2409-2469). However, a single formula or table is by no means sufficient to exhibit the true state of affairs completely, and on this account may in fact be quite misleading. The accompanying diagram Fig. 1 illustrates this remark. It contains various curves calculated from algebraic expressions for minimum cost of a reinforced concrete beam designed to resist a specified bending moment, and it shows directly the economical stress-ratio for various ratios of cost of steel and concrete. Depending on what are the basal assumptions, different curves are obtained, as shown. The equation deduced by Mr. Hanna is one of these, while the calculations of Mr. Church are represented by one of another group (fixed steel stress, width b constant). Evidently, if each of these curves has a certain degree of validity, no one of them can represent the problem in its entirety. Fig. 2, which contains these same curves replotted with economical percentage of reinforcement as ordinates instead of economical stress-ratio, shows a closer grouping of the curves, but still leaves them far enough apart to make necessary further study of the subject.

The principal modifying factor is pointed out in the letter reproduced below, and a conclusion

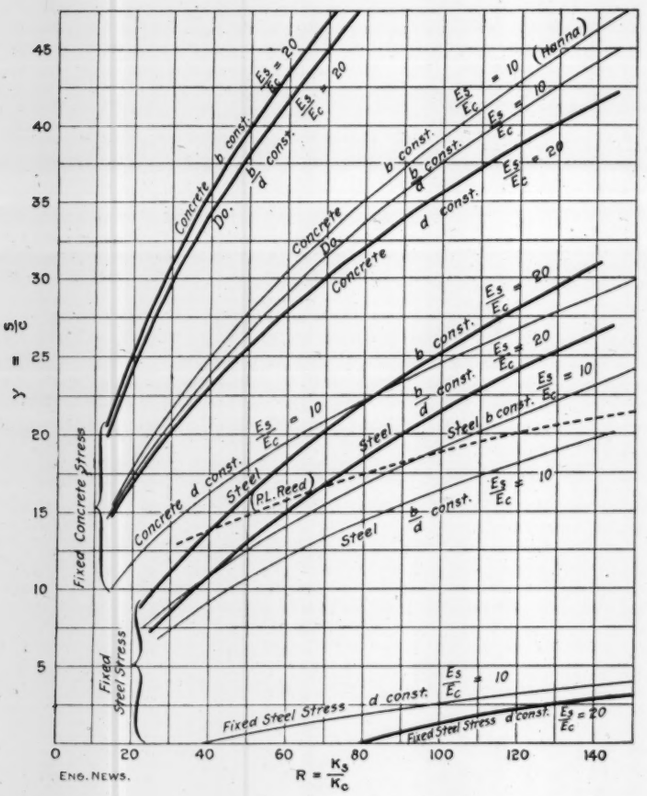

FIG. 1. CURVES OF APPARENT ECONOMICAL RATIO OF STRESSES IN STEEL AND CONCRETE, FOR VARIOUS RATIOS OF COST.

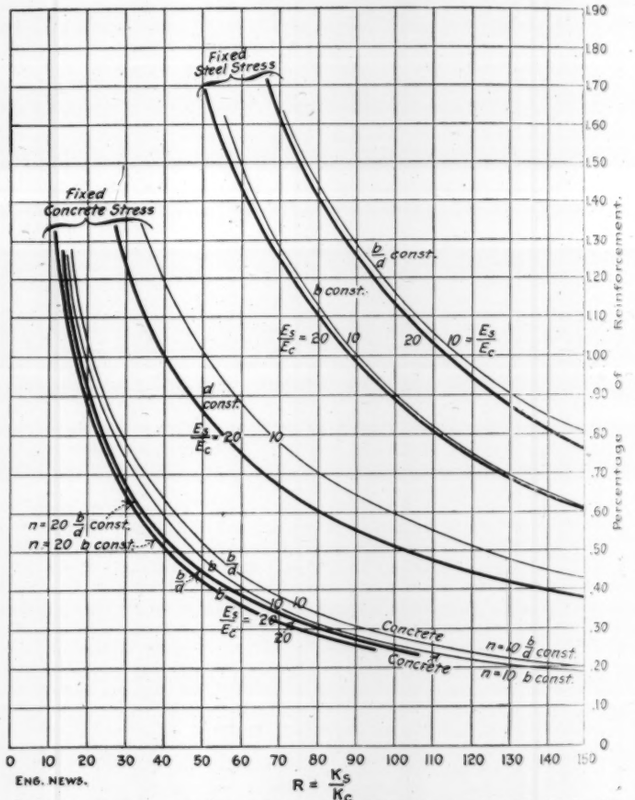

FIG. 2. CURVES OF APPARENT ECONOMICAL PERCENTAGE OF REINFORCEMENT, FOR VARIOUS RATIOS OF COST.
[These curves derived from those of Fig. 1 by replotting.]

of rather wide applicability is drawn by the writer of the letter, Mr. P. L. Reed, as to the effect of this factor. Mr. Reed suggests that the steel stress must ordinarily be kept below a definite limit. Mr. Hanna had assumed a fixed concrete stress but varied his steel stress arbitrarily, without regard to safe limits. Prof. Church, it seems, had also taken a partial view, but the opposite one,

by assuming a fixed stress in the steel and basing his deductions entirely on this calculation, paying no regard to the case where the concrete stress sets the limit. Mr. Reed shows that the two assumptions give widely different results, and infers that the true condition is intermediate: that the true point of economy lies where the limiting stresses in steel and concrete are reached simultaneously. We take this occasion, following Mr. Reed's letter, to present some curves we have calculated, which to a large extent support this conclusion, show the extent of its applicability, and suggest the exceptional cases. The subject is important enough to warrant consideration at some length.

Sir: In your issue of February 21, 1907, appears an interesting paper entitled "Economic Design of Reinforced Concrete," in which the author discusses the effect of relative costs of steel and concrete on the design of reinforced concrete for maximum efficiency and gives his results in the form of tables showing percentages of steel to be used under varying conditions of costs of materials and character of concrete.

It seems to the writer that these tables are, unfortunately, for the most part unavailable for practical use and that the conclusions are unsafe as a guide, through what was probably an oversight in the mathematical deductions.

In the equation at the foot of the second column on page 203, the author gives an ingenious expression for the cost of a unit length of a concrete beam, in which occurs the quantity c, "the unit compressive working stress in outside fiber of concrete." This quantity c is treated as a constant in the subsequent differentiation, from which the values in the tables are computed.

If steel is to be used in excess so that the compressive stress in the surface of the concrete limits the resistance of the beams, it would be proper to assign a limiting value to this unit stress and treat it as a constant, but as the tables show, there is for the most part a relative deficiency of steel, causing the allowable stress in the metal to become the governing condition, and the extreme fiber stress in the concrete becomes a variable.

If $s \div y$ be substituted for c in the author's equation referred to, at bottom of page 203, and the derivative with respect to y equated to zero, there will result:

$$9\,y^2 - 11\,r\,y + 4\,r^2 - 1.5\,R\,r = 0$$

in which

$y = s/c$ = ratio of stress in steel to extreme-fiber stress in concrete

$r = E_s/E_c$ = ratio of modulus of elasticity of steel to that of concrete.

R = ratio of cost of steel to cost of concrete per cubic unit.

If from this equation [see remark below concerning this equation—Ed.] a table be computed to compare with the author's first, omitting the last column, it will look like the following:

$R =$ Cost of 1 cu. in. steel. / Cost of 1 cu. in. concr.	$y =$ Stress in steel. / Stress in concrete.	$p =$ Percentage of steel.
40	13.8	1.62%
50	14.8	1.36%
60	15.7	1.24%
70	16.6	1.13%
80	17.4	1.65%
90	18.1	.98%
100	18.7	.93%
110	19.4	.88%
120	20.0	.83%
130	20.6	.79%

As the above table is based on the assumption that the stress in the steel is the limiting condition and the unit stress in the steel is a constant it is believed that it shows the economical percentage of steel where the steel is not in excess, or practically throughout the table for steel with an elastic limit of 30,000 lbs. per sq. in., taking the elastic properties of the materials to be in accordance with the author's assumptions.

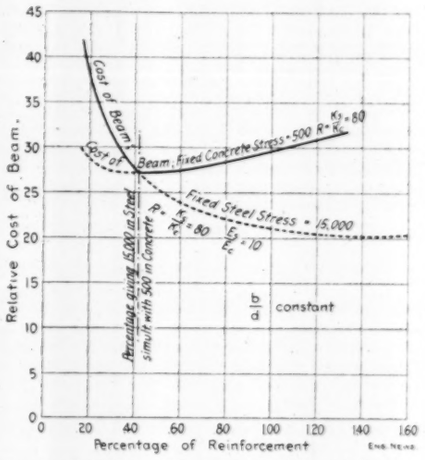
Relative Cost of Beam.
Percentage of Reinforcement
Cost of Beam
Cost of Beam, fixed Concrete Stress = 500
Fixed Steel Stress = 15,000
Percentage using 15,000 as Steel simult with 500 in Concrete
a/b constant
Eng. News

Fig. 3. A Curve of Cost of a Reinforced Concrete Beam with Varying Percentage of Reinforcement.

Based on constant shape of cross-section $\left[\frac{\text{width}}{\text{depth}} \text{ constant}\right]$.

For steel costing 80 times cost of concrete per cubic foot and $\frac{E_s}{E_c} = 10$.

Taking now steel with an elastic limit of 50,000 lbs. per sq. in. it will be seen from the second and fourth columns of the author's first table that, if the unit stress in the concrete be considered as fixed at its safe limit, economy is attained by reducing the quantity of and increasing the stress in the steel at least up to its safe limit in every case. Inspection of the writer's table above shows that if the unit stress in the steel be considered as fixed at its safe limit, that economy is attained by increasing the quantity of steel and the stress in the concrete at least to its safe limit in every case. The conclusion follows that for steel with an elastic limit of 50,000 lbs. per sq. in., the maximum economy of material will be attained in all cases covered by the author's first table, when steel and concrete are in such proportions as to bring to each simultaneously its maximum allowed stress, which is the usual method of designing concrete reinforcement. Yours truly,

P. L. REED.

U. S. Naval Station,
Olongapo, P. I.
April 1, 1907.

Before proceeding, we call attention to the fact that Mr. Reed's equation does not follow from the assumptions used by Mr. Hanna (rectilinear stress variation in the concrete). This is shown by Fig. 1, where Mr. Reed's equation is represented by a curve calculated for $r = 10$. Our own curve for this same value, and for the same assumption of constant width of beam (b constant) intersects this near the point where R, the cost ratio, equals 92. It is calculated from

$$6\,y^3 + 6\,ry^2 + 2\,r^2y - R\,(3\,ry + r^2) = 0.$$

While this will change the figures tabulated by Mr. Reed, the changes are not great enough to vitiate his argument.

The difference between the curves for fixed steel stress and fixed concrete stress is due to the fact that entirely different physical conditions govern the calculation in the two cases. The curve of cost of a reinforced concrete beam with varying reinforcement consists of two independent branches, as illustrated by the curve in Fig. 3. Under the conditions for which Fig. 3 was calculated, a reinforcement of 0.60% requires a heavier (hence more costly) beam when the concrete must be limited to 500 lbs. per sq. in. than when we are permitted to work the steel up to 15,000 lbs. irrespective of the concrete stress. In actual practice, of course, we are very properly limited both in the steel stress and in the concrete stress, and therefore, when the reinforcement is once decided upon, we must design the beam heavy enough to get within the limit in both materials. Thus, using 0.60% reinforcement in the present case, the stress limit in the concrete requires us to use a beam costing 27.5, as against a cost of 24 if the limiting steel stress alone were considered.

Under the circumstances, the true cost curve is the broken curve shown by a full line in Fig. 3, and the interesting question is to find the point of least cost on this curve. Mr. Hanna's equation determines the minimum point on the curve of fixed concrete stress, which in Fig. 3 occurs at 0.34% reinforcement. The method followed by Prof. Church and Mr. Reed finds the minimum of the curve of fixed steel stress, which in our case occurs at 1.45% reinforcement. Actually neither of these points is of interest to us. What we really want to know is shown by inspection of the curve in Fig. 3, namely that the least cost results when we use 0.42% reinforcement, just enough to produce the limiting stresses in concrete and steel simultaneously.

The composite curve of Fig. 3 evidently is mathematically discontinuous, and cannot be studied by the mathematical method of Prof. Church and Mr. Hanna. The best way of obtaining a survey of the actual cost conditions is to compute relative costs for various reinforcements and plot these in a curve, like that of Fig. 3. Such calculations are quite laborious, as

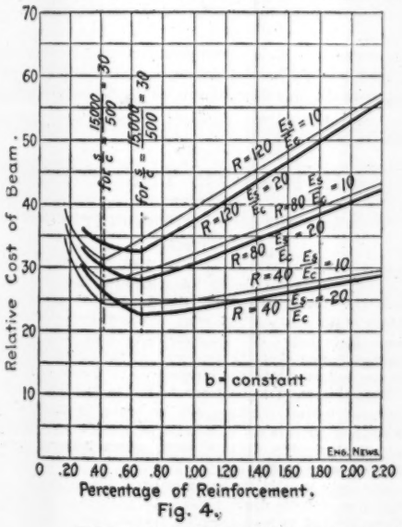

Fig. 4.

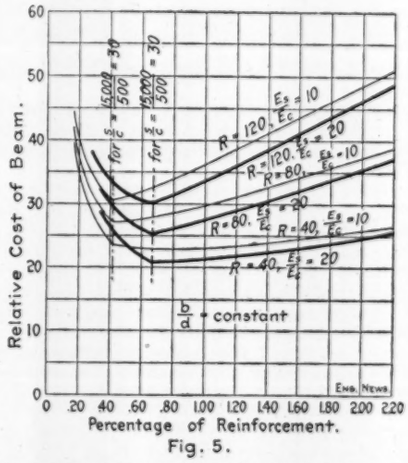

Fig. 5.

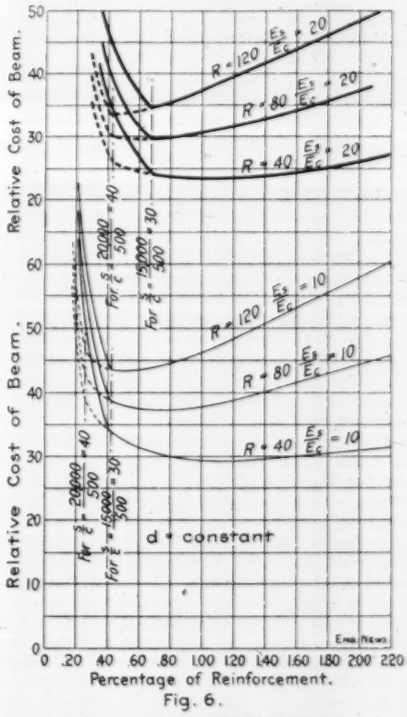

Fig. 6.

FIGS. 4-6. CURVES OF TOTAL COST OF A REINFORCED CONCRETE BEAM WITH VARYING PERCENTAGE OF REINFORCEMENT.

a considerable number of individual curves requires to be drawn in order to show how variations in the several assumptions alter the case. But they offer the great advantage of a graphical representation of how the cost of a beam is altered by using more or less steel.

We have calculated and plotted a series of 18 such curves, and present them in Figs. 4 to 6 herewith. Each individual curve represents the total cost of a beam designed to resist a given bending moment. The curves drawn are based on

Two values of $E_s \div E_c$, namely 10 and 20.

Three values of $\text{Cost}_s \div \text{Cost}_c$, namely 40, 80 and 120.

Three conditions of design, namely fixed width of beam [b constant]; fixed shape of cross-section or ratio of width to depth [$b \div d$ constant]; and fixed depth of beam [d constant].

The influence of the third factor is quite material, though both Mr. Hanna and Mr. Reed have ignored it in their calculations. It has even greater influence on the location of the minimum of the two component curves, which minima are given completely by the diagrams Figs. 1 and 2. In Fig. 2, for example, we see that, when the concrete stress is fixed and the steel stress is not limited, the economical percentage of reinforcement is just about twice as great when the beam is to be of *fixed depth* than when either the width or the ratio of width to depth are fixed.

Why this effect occurs is readily explained. It is well known that a beam is more efficient the greater its depth in relation to its width. Therefore, when the breadth of a beam is fixed, higher efficiency will be secured by increasing the depth and decreasing the reinforcement. When the depth is fixed, efficiency is promoted by decreasing the width and increasing the reinforcement. In either case there is an economical limit to such increased efficiency, imposed in the first case by the increased amount of unutilized concrete cross-section, in the second case by the increased cost of the reinforcement, and in either case determinable by eliminating from the equation of cost all variable factors except $s \div c$, or else the percentage of reinforcement, and determining the value of this variable when the cost is a minimum.

Referring now to the three curve-sheets, Figs. 4 to 6, attention is drawn to the fact that in most cases the minimum cost is found at that point where the permissible stresses in steel and concrete are fully utilized. As the general trend of the curves indicates, the greatest tendency for departure from this rule is when steel is cheap; for example, the curve for $R = 40$, $E_s \div E_c = 10$, in Fig. 5, shows a minimum at 0.64% reinforcement, where the strength of the steel is not fully utilized; a beam with 0.42% reinforcement, which reaches the limits of 15,000 and 500 lbs. per sq. in. simultaneously, costs a trifle more.

Aside from this tendency, the case of Fig. 6, when the depth of beam is fixed, represents an exception in almost every instance. In fact we may say as a general rule that, when a beam of fixed depth has to be designed, it is uneconomical to utilize the full strength of the steel; a cheaper beam can be designed when much more reinforcement is used. For instance, if steel costs 80 times as much as concrete, and the concrete has a modulus of elasticity of 3,000,000, and can be stressed to 500 lbs. per sq. in., then 0.70% reinforcement should be used for a beam of fixed depth; this will give a beam nearly 3½% cheaper than if the steel were stressed to 15,000 lbs. per sq. in. (0.42% reinforcement), and nearly 13% cheaper than if the steel were stressed to 20,000 lbs. per sq. in. (0.25% reinforcement). Therefore the case of fixed depth of beam should always be investigated, on the basis of known $E_s \div E_c$, known cost ratio, and known limiting stresses, to see whether the minimum of the concrete curve is not reached before the steel stress is fully utilized, and to fix the reinforcement which gives this minimum.

None of the curves shown in Figs. 4 to 6 show a minimum on the steel (left-hand) part of the cost curve, within the limits employed.

It will be recognized that practically there are only two possibilities as to point of minimum cost: either it occurs at that point where both materials are fully utilized, or it occurs somewhere on the concrete curve with an over-reinforced beam. In the first place, it is readily seen that the composite curve can never have two minima, one for under-reinforcement and one for over-reinforcement. For, the curves of the steel group in Fig. 2 are always above those of the concrete group; the two groups do not cross for any cost-ratio that we need consider. Therefore, if the point where both materials are fully utilized is not the true minimum, then the minimum occurs on either the steel curve or the concrete curve, but not on both. In the second place, consideration will show that in no practical case will the steel curve, i. e., the cost curve of the under-reinforced beam, ever give a minimum. Fig. 2 shows that the minimum curves for fixed steel stress practically never get down to as low a reinforcement as corresponds to the point of full utilization of concrete. We can of course manufacture an instance to show the contrary: If $E_s \div E_c = 20$, $c = 400$ lbs. per sq. in.; $s = 12{,}000$ lbs. per sq. in., then the reinforcement for full utilization is 0.67%; from Fig. 2, with b constant, steel costing over 135 times as much as concrete will make the under-reinforced beam slightly the cheapest. But such cases will not occur in practice. In practice, therefore, we must look for the minimum cost either at the point of full utilization or in the range of the over-reinforced beam.

The ratio of permissible stresses has considerable influence on whether or not an over-reinforced beam will be cheapest. To illustrate this, let it be remembered that the curve for fixed concrete stress, in Fig. 3, may be joined with any one of a variety of steel curves depending on the ratio of the allowed stresses. That drawn in Fig. 3 is for a stress-ratio of 30, and to bring this out we have marked the component curves "For concrete stress = 500," "For steel stress = 15,000," although the curves are not tied to these numerical values but only to their ratio, and apply equally to the pair 12,000-400, and 18,000-600. But when the allowed stress in steel is greater than 30 times the allowed concrete stress, then a new steel curve, to the left of that in Fig. 3, must be drawn; similarly, when the ratio of permissible stresses is less than 30, the steel curve shifts to the right. In Fig. 6 we have drawn two sets of steel curves, for the stress-ratios 40 and 30 respectively, to illustrate this. The effect of this may be studied by referring (in Fig. 6) to the curve for $R = 80$, $E_s \div E_c = 20$; with a stress-ratio of 30, the cheapest beam is secured by reinforcing for full utilization (0.67%), but when the stress-ratio is 40, the beam of full utilization (0.42%) costs more than an over-reinforced beam with 0.61% of steel.

The matter then resolves itself into the following conclusions:

1. When a beam is strictly limited as to depth, as for example in the case of a lintel girder, the cheapest beam is very probably an over-reinforced beam. This depends on the ratio of permissible stresses; on the ratio of cost of steel and concrete; and on the ratio of moduli of elasticity. The curves in Fig. 1 should be used to determine the matter. The stress ratio fixes a horizontal line on this diagram. If the appropriate concrete curve is below this line, on the vertical through the appropriate cost-ratio, then an over-reinforced beam is the cheapest. By referring to Fig. 2 the precise percentage of reinforcement giving this maximum economy can be read off.

2. When the beam is not governed by the condition of fixed or limited depth, it comes under the classes represented by Figs. 4 and 5. A floor-slab, which must be designed for a given bending moment per foot width, would be classed with Fig. 4, b constant; while a girder would generally come under the case of b/d constant, Fig. 5. Generally in these cases the cheapest beam will be that which is reinforced for full utilization of both concrete and steel. If there is any question about the matter it may be investigated with the aid of Fig. 1, as noted for the beam of fixed depth. The chances for obtaining economy by over-reinforcing are greatest when steel is cheap, when concrete is expensive, when the ratio of permissible steel stress to [illegible] concrete stress is high, and when [illegible] concrete has a high modulus of elasticity.

3. Whenever the over-reinforced beam is cheapest, there is a fairly wide range of percentage of reinforcement, about the point of least cost, within which the cost will vary only slightly. However, in the case of fixed (or limited) depth of beam, the cost increases more rapidly with variation from the exact point of least cost than it does in other cases.

The discussion and calculations given above leave out of account several pertinent matters. The cost of a reinforced-concrete beam is not so simple a product as is indicated by the formula

$$\text{Cost} = bd + Rp\,bd.$$

The concrete below the steel (the depth d being counted from compression side to centre of steel only) is an additional expense which may be considerable in small beams. The cost of forms is not absolutely a constant but varies somewhat with the dimensions of the beam, thereby reducing the apparent cost-ratio R. The cost of the reinforcing steel, in place, is probably not absolutely proportional to the quantity of reinforcement. If it may be represented by a sum of two terms, one being proportional to the weight of steel (first cost and handling) while the other is a constant for the beam (bending, assembling and placing), then the mathematical analysis and the curves above given are not affected, but if it varies in any other manner the preceding figures will be subject to slight modification.

Again, the weight of the beam is not constant for any given curve in Figs. 4 to 6, but increases with decreasing percentage of reinforcement. The dead-load moment therefore increases as the percentage of steel is reduced, and the beam must be designed for a higher total moment capacity, hence will cost more. This affects the curves approximately as though a new base-line were drawn for each diagram, starting at a point on the Y-axis below the zero-point, and sloping slightly upward toward the right. Evidently, under these conditions the point of least cost will tend to shift toward the right, i. e., toward the region of higher reinforcement. This effect is of course greatest when the ratio of dead load to total load is high.

These, and still other factors, perhaps, complicate the matter. No single one of them, it seems, can be of sufficient influence to make material change in the conclusions and data above presented. This consideration, and the very great variability and complexity of the accessory factors in question, lead us to believe that the present discussion may be serviceable in actual work.

LETTERS TO THE EDITOR.

Experience with Steel Longitudinals Under Railway Track.

Sir: In your issue of June 13, 1907 (p. 643), Mr. J. W. Schaub, in an article on "A Suggested Development in Railway Track" mentions the Lindenthal experimental track with longitudinal steel sleepers under the rails, and states that "it is impossible to keep such track in surface," and that the tendency of the prism of broken stone ballast under the sleepers is to flatten out.

This statement is contrary to the facts. The track is keeping perfect surface, and no wave in front of the wheels is observable. There is no trouble with the longitudinal rigidity of this track, which behaves in that respect as expected.

The only trouble is the creeping of the rails, the track being on a 0.6% down grade. This creeping is expected to be stopped by anti-creeping devices now being applied.

The creeping on this experimental track 1,000 ft. long is, however, not greater than it is with the standard cross-tie track at each end of it. The force causing the rails to creep is so great that it had a tendency to cant the cast-iron blocks under the rails, cracking and breaking off the flanges on the blocks. They have been replaced with wooden blocks, which are better for the insulation of the rail, acting as a conductor for the electric block signals. It is recognized that the creeping on this track can effectually be stopped by a slight change in details of future sleepers.

The principal purpose of this system, with deeply anchored longitudinal steel supports directly under the

rails, is to keep the rails in permanently perfect surface and alignment under heavy fast freight trains.

The steel sleepers required frequent tamping the first few months to obtain a proper bearing and solid anchorage in the stone ballast. After that there was no further trouble from wave-action.

Gustav Lindenthal.

45 Cedar St., New York City, June 14, 1907.

[Mr. Lindenthal's track was illustrated and described in our issue of Nov. 30, 1905, p. 576.—Ed.]

Expansion Joints in Concrete.

Sir: In private correspondence received since the publication of my article on "Expansion Joints in Concrete," in your issue of May 2, 1907, it seems that my individual position and opinions in this matter have been misunderstood. Among those acquainted with official documents and official reports, such as this article was taken from, it is understood that in them individual opinions are, as a rule, submerged. In order to state definitely what may be inferred from a careful reading and consideration of the article as a whole, I would like to give you the following:

Expansion joints in concrete are considered by many to be a necessity. Some engineers still hold to the idea of a monolithic concrete structure. The evidence of this is shown in the failures cited in my report. For that reason the question of expansion joints was taken up in considerable detail and improvements in the design of expansion joints were suggested. The latter part of the report dealt with what I consider to be a better plan, whenever it is possible to use it in any structures. In other words, my opinion is to avoid expansion joints in every possible way, and to use the block form of construction, the blocks either being poured in place or handled in large blocks which set in the air, as is done by the New York Dock Department in their bulkhead construction. If a sufficiently great length of time elapses between the pouring of one block in place and the pouring of the adjacent block, the difficulty from the contraction of the concrete in setting is avoided almost as well as if the block were permitted to set in the air and then put in place. The question of whether the blocks which set in air are more durable than blocks poured in place, when acted on by ice and waves between high water and low water, as in quay walls when the tide rises on partially set concrete, is not fully determined, but such evidence as I have, points to the greater durability of blocks set in air and afterwards set in place.

Trusting this will set my own position straight, I am,

Very respectfully,

L. F. Bellinger,
Civil Engineer, U. S. N.

New York, June 13, 1907.

On the Application of Flat-Plate Theory to Slab Floors of Reinforced Concrete.

Sir: In your issue of May 30, Mr. C. A. P. Turner, in discussing flat reinforced-concrete plates or slabs supported on all sides, stated that such a slab is at least three times as strong as one supported on two sides. His method of proof is not conclusive. The fact that the center of gravity of the triangle of load that goes to each support is one-sixth of the span from the support, while with only two supports the center of gravity is one-quarter of the span distant from the support, does not gage the relative bending moments in a section of the slab near the middle. This triangle is not perfectly rigid, and it does not act independently, but must be supported by the other triangles. The necessity for mutual support adds stress in one triangle due to load on the others.

It has been stated in published articles and communications, and it is so presented in works on the subject of reinforced concrete, that a square slab is similar to a flat steel plate supported on four edges. The theory of a flat plate is referred to as being applicable to such slabs. This theory, however, has no direct application to flat slabs of reinforced concrete. It is based on assumptions which include a material capable of taking tension and compression in all directions, and a flat steel plate is in fact subject to tension in all directions near the bottom. Concrete, of course, cannot be counted on to take tension, and rods cannot be placed in all directions. Hence on this assumption of analogy there can be no basis of theory for finding the stress in the rods.

The critical part of a square slab is at the center of the square. This part should be reinforced more strongly than the parts nearer the supports. Reinforcement placed near the supports and parallel thereto, if equivalent to that used across the center, is wasted. This removes the reinforced-concrete slab still farther from the flat plate theory, because that theory assumes a plate equally strong in all parts.

Yours very truly,

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., June 10, 1907.

A Free Labor Exchange for Italians.

Sir: Italian immigration into the United States has grown very rapidly in the last 27 years. It was only in 1880 that the number of Italian immigrants coming into this country exceeded 100,000 (123,054); and from that time Italian immigration has constantly increased. During the fiscal year ending June 30, 1906, it reached 273,100—taking the head of the column over all nationalities which contribute to form the large stream of immigration to this country.

The larger percentage of Italians coming into the United States are uneducated, and it is rare that any are found who understand English. These people are not alone uneducated, but poor—so poor that to live they must find employment immediately upon landing.

From the immigrants' ignorance of the English language on the one hand, and the demand for labor on the other, arises the necessity for agents, to act as intermediaries between the two classes. And these agents, with but few exceptions charge exorbitant fees both to the laborers and to the people employing them. At the present time some of these agencies are charging only the applicants for work, not the employers; but, in one way or another, they always manage to exploit the new-comers.

Struck by this condition of affairs, some American gentlemen last year decided to form an organization for the purpose of creating a free labor exchange, to act as an intermediary between those seeking employment and those who would employ them. These gentlemen are, Mr. Augustus Healy of New York; Mr. Giovanni P. Morosini, banker, of New York; the late Mr. Joseph Ratti, of Bloomsburg, Pa.; Mr. Joseph Tuoti and Mr. C. A. Aimone.

The office was opened in April, 1906, under the name of the "Labor Information Office for Italians," at its present address, No. 59 Lafayette St., New York City; and, although it threatened some rather powerful interests, from the date of its opening up to June, 1907, it had secured employment for 7,194 persons—of which number 2,493 were employed in the last five months. Also during this last period 319 employers made application for help, and 5,532 Italians were advised as to the conditions of work, wages, etc.

The office has still another aim, which is of national interest—the distribution of new-comers throughout the United States. It is well known that most of the Italians coming to this country settle in the large cities of the East; while they would be of much better use to their new fatherland if they would go to the Western and Southern agricultural regions.

The Labor Information Office for Italians does its best to assist any who express a desire to devote themselves to agricultural pursuits, giving them detailed information as to the most suitable sections of the United States, etc. Great results from this branch of the work cannot be expected, because the financial circumstances of Italian immigrants prevent them from grasping all the opportunities that the United States offer to those willing to become farmers. The extreme poverty of these people prohibits their either buying lands or waiting for crops to grow; for they must live in the meantime.

Notwithstanding this, the office hopes in time to succeed in placing a good number of the new-comers in the agricultural districts of the United States.

G. di Palma-Castiglione, Manager.

New York, June 13, 1907.

The Effect of the Storm of October, 1906, on the Cleveland Breakwater.

Sir: The article in Engineering News of May 23, 1907, on the stone breakwater at Cleveland, O., is based upon an interview of Mr. Cushing with the undersigned when submitting a report to the Chief of Engineers on the damage caused to the breakwater by the storm of October, 1906.

The effect of this storm on the Cleveland breakwater is considered of sufficient interest to the engineering profession to merit a somewhat more extended discussion than it received in the article. The damage inflicted differed materially from that caused by storms on any breakwater with which the writer has had experience. While he has observed waves tear stone of considerable size from the exposed side of a breakwater and carry them over it into the harbor, or roll them down the slope as they reacted, no such action occurred at Cleveland; nor has there been any appreciable settlement of the foundations as is reported in the breakwater at Buffalo. The limited damage noted was in the stone pavement on the harbor side, and was confined to a space between the top of the breakwater and a line 6 ft. below the water surface. While there was a slight settlement of the top of the breakwater and of the lake face, several stone on the harbor side have moved so as to have an appreciably greater elevation than when originally placed in the work, their motion being approximately at right angles to the direction of a force striking the lake side of the structure, and opposed to the action of any wave which could pass over it and hit it on the harbor side.

In the interview it was attempted to explain this action by assuming a pressure created in the interior of the breakwater when it was struck by a wave and transmitted in all directions; but a much simpler theory will account for all the phenomena observed. The pavement had been carefully laid and the joints chinked. The heavy jarring of the structure during storms would tend to compact the loosely deposited core whether composed of rubble, shale or sand, and cause it to settle, separating from the pavement which, due to the closeness of its joints, cannot follow this motion. The pavement would then become an arch and the pressure from wave action, instead of being transmitted through the body of the breakwater, would pass over it in an arch from 30 to 36 ins. in thickness. Such an arch would either yield at the spring line or become distorted, flattening on the side on which the pressure is exerted and bulging on the opposite side. Many of the footing stones of the pavement on the harbor side have slid out, and at some places where they have held, a distortion of the form of breakwater is observable, the harbor slope having become steeper and the lake slope flatter. Moreover, little damage occurred in sections where the top course of pavement had not been placed, and the experiment is being tried in completing these sections of omitting the cut stone angles and forming the top of the breakwater of large stone weighing from six to eight tons rather loosely placed, which can settle with the structure and relying on their weight rather than the bond to hold them in place; in other words, destroying the key to the arch.

Similarly in the new work the pavement is to be replaced by large stones, which, it is expected, will average about six tons in weight. These stones will extend into the work from 5 to 6 ft., but be more loosely placed than in the pavement. To obtain these large stones there will be a certain amount of smaller stone quarried which can be cheaply disposed of in the interior of the breakwater in place of some of the shale heretofore used.

While the article was carefully written, and was sufficiently accurate for an ordinary newspaper interview, it requires correction in certain details when printed in a scientific journal. The original design for the breakwater submitted by the Board of Engineers, of which Colonel Smith was a member, did not contemplate the use of a sand core. While of the general form shown in cross section as the first design, the section printed is derived from the project submitted by Colonel Kingman, and afterwards modified by him to the second cross section given.

A description of the breakwater will be found in a paper by Colonel Kingman on harbors on Lakes Erie and Ontario published in the Transactions of the American Society of Civil Engineers, Vol. LIV., Part D.

Very respectfully, C. McD. Townsend,
Lieut.-Col., Corps of Engineers, U. S. A.

813 Prospect Ave. S. E., Cleveland, O., June 1, 1907.

LOCOMOTIVE FIREBOXES WITH EXPANSION SIDE SHEETS.

Various experiments and devices have been tried with a view to reduce the troubles with locomotive fireboxes, and some of these are reviewed in our editorial columns, but the most extensive use in regular service of fireboxes specially designed to allow for the varying and irregular expansion and contraction movements has been made on the Hocking Valley Ry. and the Ohio Central Lines (Kanawha & Michigan Ry. and Toledo & Ohio Central Ry.). The equipment of these three roads is under the jurisdiction of Mr. S. S. Stiffey, Superintendent of Motive Power, at Columbus, O., and more than 80 of the locomotives are now fitted with the Laughridge firebox, which is especially designed to allow for the movements due to temperature variations. Some of the engines have been in use for more than three years. This type of firebox is the invention of Mr. W. H. Laughridge, and is manufactured by the Laughridge Firebox Co., of Dunkirk, N. Y. Mr. Wm. C. Marsh, Vice-President and General Manager of the company, informs us that there are over 100 of these fireboxes now in service on the roads above mentioned, and also on the Buffalo, Rochester & Pittsburg Ry. and the Minneapolis, St. Paul & Sault Ste. Marie Ry. The company also has on hand orders for fireboxes for 26 more locomotives.

The Laughridge firebox is of the Belpaire type, and the side sheets are made in about four sections, with vertical seams, as shown in Fig. 1. The edges of the sections are slightly separated to form open joints, and the seams are closed by vertical strips of U-section, on the inside of the firebox. The flanges of the strips are riveted

to the edges of the two adjacent plates, and the hollow rib thus formed allows for all the varying movements. The strips are of the same grade of steel as the plates, and are pressed to shape by a former. They are shown in detail in Fig. 2. A curved back head also provides for longitudinal movement, while both longitudinal and vertical movement is provided for by a mud-ring consisting of a Z-shaped copper bar, 5/8-in thick. This bar (with rounded angles) has its vertical flanges riveted to the inner and outer plates, while its horizontal web forms the mud-ring proper. Where the ordinary rectangular mud-ring is used, the inside sheet is short, stopping about 4½ ins. above it; a horizontal copper strip of U-section closes the gap, having its upper flange riveted to the plate and the lower flange to the mud-ring. This is shown in Fig. 3.

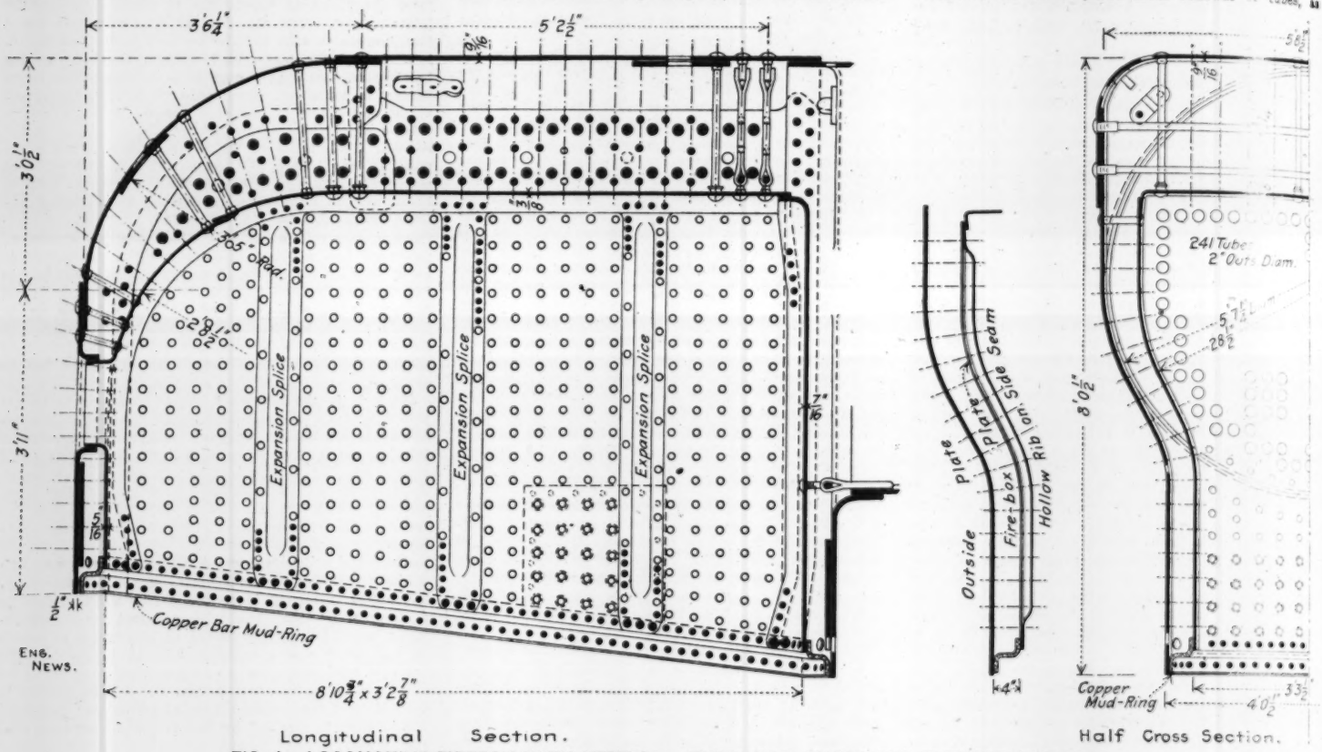

FIG. 1. LOCOMOTIVE FIREBOX WITH VERTICAL EXPANSION JOINTS AND FLEXIBLE MUD-RING.
Laughridge Firebox Co., Dunkirk, N. Y., Builders.

The use of the Laughridge firebox was first introduced in 1902 on some consolidation (2-8-0) freight engines of the Hocking Valley Ry., and has since been applied also to other types of engines, including passenger engines of the 4-4-0 type. We give below an abstract of a report made by Mr. S. S. Stiffey, Superintendent of Motive Power of this road, on the comparative results obtained with two similar engines of this latter type, and running in the same service; one had an ordinary firebox and the other a firebox of the Laughridge type. It is estimated that for a period of ten years the cost of maintenance (and renewals of ordinary firebox) would be $600 for the Laughridge and $3,400 for the ordinary firebox, showing a saving of $2,800 in favor of the former. This is exclusive of the saving due to the shorter time which the former engine will spend in the shops. The report is for the period of two years ending with March, 1906:

These engines are working in a district with very bad water. While the life of a firebox is very much shortened and the cost of maintenance very materially increased because of this fact, the relative difference between the life of the Laughridge and the ordinary firebox, and the cost of maintenance of same, will remain the same under ordinary or most favorable conditions. As a basis of comparison, we have used passenger locomotives Nos. 76 and 80. Engine No. 76 was built in April, 1900, and equipped with an entirely new firebox of the ordinary type in March, 1904. Engine No. 80 was built in March, 1904, and equipped with the Laughridge type of firebox. Each of these engines has cylinders 18 × 26 ins., and the maximum boiler pressure is 180 lbs. These engines are of practically the same type, with the exception of the firebox; the fireboxes are of the same age, and the engines have worked side by side over the same track and in the same territory.

In October, 1905, after running 19 months and 108,333 miles, engine No. 80 (equipped with Laughridge firebox) had all tubes renewed to obviate the possible collapsing of tubes due to scale packing and the fact that boiler was full of mud. Aside from sag, occasioned by scale packing and mud, the tubes were in perfect condition and have so been maintained without re-beading or any attention due to the push or pull of the backhead. The expansion or welt strips connecting the sectional side sheets in this firebox have received no attention; they are in good condition, and will not have to be renewed for at least six months or before September, 1906, making the life of these strips at least 30 months, or 2½ years.

The average cost of renewal of side strips is about $135 per engine. What the life of the side sheets in this engine or of the Laughridge firebox in this district will be, we are as yet unable to determine from experience, but ten years is not considered an extravagant estimate. The sheets in this particular engine at the present time are practically as good as new, there being no corrugations or cracks. The cost of maintenance of this firebox and the loss of time of engine from service on account of the same (aside from renewal of tubes, as above) during the period covered by this report was practically nothing.

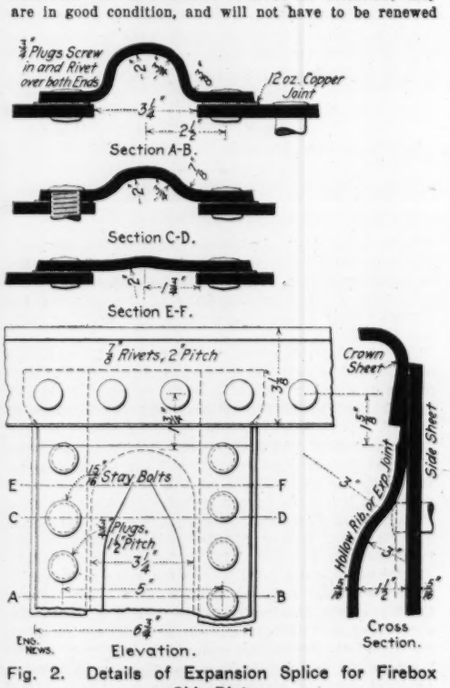

Fig. 2. Details of Expansion Splice for Firebox Side Plates.

As regards the operation of the standard firebox in engine No. 76, this engine had 90 tubes renewed in March, 1905, and was shopped on Nov. 21 for thorough repairs, including renewal of all tubes and three-quarters of the side sheets. This work, including stripping of engine and in addition to cost of flues, cost approximately $375. During the time this engine was in service previous to date of thorough repairs as above (which is the time used for this comparison) it was several times taken out of service and returned to the shop for renewal of a total of 60 stay-bolts, all of which were in the side sheets. This necessitated the stripping of engine to make repairs at a cost of about $165, regardless of and over and above cost or loss of time of engine from service while repairs were being made. This engine will run about 20 months from date of repairs, before requiring renewal of the entire firebox, making the life of an ordinary firebox in this particular district, with the necessary repairs and attention, about 40 months.

This estimate of the life of an ordinary firebox with the repairs as above, is extremely generous, as it will be noticed that this is the same length of time that the present firebox ran when new, before requiring these extensive repairs. Allowing the same percentage of breakage of stay-bolts in side sheets for the second 20 months, or after application of three-quarter side sheets, as for the first 20 months (which as a matter of fact, because of age, must be greater), the cost of repairs and maintenance of this box for the 40 months (regardless of loss of time of engine from service on account of repairs and application of three-quarter sheets) would be as follows:

Cost of maintenance first 20 months	$165
Cost of application of three-quarter side sheets at end of first 20 months	375
Cost of maintenance second 20 months	165
Total	$705

The roundhouse work on firebox and tubes of engine No. 80 equipped with Laughridge firebox during the period covered by this test as above (two years) was over 60% less than on engine No. 76 equipped with standard firebox, for the same period of time. The Hocking Valley, Toledo & Ohio Central, and Kanawha & Michigan railway companies have over 80 locomotives equipped with the Laughridge firebox which have been in service from three months to over three years. The engines so equipped which have been in service a suf-

...length of time to justify a statement being made with reference to their condition, have shown practically complete elimination of breakage of stay-bolts.

There is a very material increase in the life of a set of tubes and a very great increase in the life of the firebox sheets. As previously referred to in this report, when engine No. 80 had tubes renewed in October, after 19 months' service and after making 108,333 miles, it had had no repairs whatever to the tubes, and the beads on the tubes were practically as good as new. Even if there were no decrease in the breakage of stay-bolts or increase in the life of a set of tubes, and an overcoming of the disastrous results from cracked side sheets, leaky stay-bolts and flues, the fact that the life of the firebox is so greatly increased, and the further fact that it will effect a saving of about 15% in the use of coal, much more than justifies the application of this firebox.

The life of the Laughridge firebox is maintained to at least three times the life of an ordinary firebox, simply by renewal of the expansion strips. This work can be done at a small expense in the roundhouse, without stripping the engine, and with a very short loss of time of engine from service. In the maintenance of an ordinary firebox to renew or replace stay-bolts or to apply three-quarter side sheets, the expense is very much greater. The length of time that the latter locomotive is kept out of service for these repairs and application of side sheets is also greater.

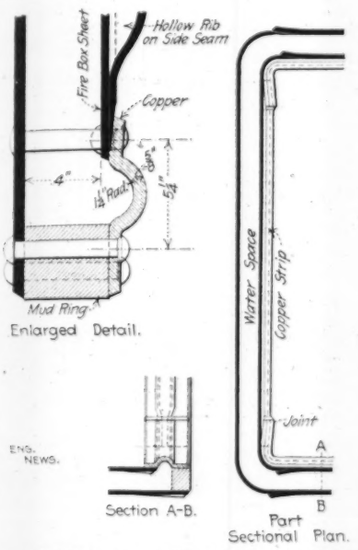

Fig. 3. Flexible Connection of Firebox Plates to Ordinary Mud-Ring.

The following is a summary of the financial comparison given in the above report:

Laughridge firebox:	
Life of expansion strips	30 to 36 months
Ave. cost of renewing all strips	$135
Est. life of side sheets	10 years
Est. cost of maintenance during 10 years life of firebox (3 renewals of strips and all repairs)	$600
Ordinary firebox.	
Estimated life	40 months
Cost	$650
Cost of placing three-quarter sheets	$375
Cost of placing three-quarter sheets and necessary stay-bolt work, etc., for 40 months' service	$700
Cost of firebox and maintenance, 40 months	$1,350
Cost of two renewals and repairs to equal life of Laughridge firebox (10 years)	$3,400
Extra cost over Laughridge firebox (exclusive of loss in time and service)	$2,800

ENGINEERING WORKS AND SURVEYS IN THE PHILIPPINE ISLANDS.

By G. R. PUTNAM,* M. Am. Soc. C. E.

It is proposed in these notes to give an outline of the progress in engineering works and in surveys in the Philippine Islands since the American occupation, and to preface this with a brief description of those features of the islands of interest to the engineer.

The Philippines have been in contact with European civilization for over three centuries, having been discovered 29 years after the discovery of America. Manila was occupied by Spaniards 36 years before the settlement of Jamestown. The modern history of the islands is, therefore, practically contemporaneous with that of America, in comparison with which, however, their progress in public works has been very slight indeed.

*Director of Coast Surveys, Philippine Islands, 1900 to 1906.

The Philippines occupy a central position on the western side of the Pacific. Their extent of a thousand miles in latitude nearly crosses the north tropic zone, the southern limit being but 4½° from the equator and the northern limit but 2° from the temperate zone. In longitude the islands are practically on the other side of the earth; the day begins in Manila 13 hours before it does in New York, so that it is possible to send a cablegram from Manila in the evening and have it reach New York the morning of the same day. At Manila the time of sunset or sunrise varies but one hour throughout the year, and for about four months the sun is north of the zenith at noon.

Notwithstanding the extent of the group, the actual land area is not large, being only about 115,000 sq. miles, nearly equal to the territory of New Mexico or the combined area of New York, Pennsylvania, New Jersey and Maryland. Two-thirds of this area is in the two great islands of Luzon and Mindanao; there are 31 islands which have each an area greater than 100 square miles, and many smaller islands. The larger islands are long drawn out or deeply cut by gulfs, so that no point in any island is more than 60 miles from the coast.

The result of this is that the climate is distinctly of an insular character, the temperature being wonderfully equable throughout the year. In Manila the extreme range between the highest temperature of summer and the lowest temperature of winter is only about 40° F., or less than the variation which we sometimes have in a single day. The maximum of 100° F. is seldom reached; the minimum is 60° F.

The winds are seasonal; the northeast monsoon prevails from November to April; the remaining months are generally spoken of as the southwest monsoon season, this being the predominant direction of the wind, which, however, is much less constant. The rainfall varies with the monsoons on the respective coasts, the southwesterly winds bringing rain to the western coasts and the easterly winds rain to the eastern coasts. In Manila there are distinct rainy and dry seasons; February has the least rainfall and at this time the grass and vegetation are dried and parched; September is the wettest month; the average annual rainfall in Manila is about 78 ins., but in parts of the islands it is much heavier. The warmest months in Manila are April and May, which are dry. The summer months are cooler because of the increased amount of cloudiness and rain.

The Philippines lie in the track of the typhoons, which are cyclonic storms quite similar in every way to the West India hurricanes. These storms usually originate southeastwardly from the islands, and move across them into the China Sea, some reaching the China coast, others curving northward toward Japan. The whirl of the typhoon is in a direction opposite to the motion of the hands of a clock, and the air is gradually drawn in towards the center where it rises, and at higher altitudes is thrown out again in divergent currents. The presence of a typhoon brings rainy weather over a large area, but the destructive path is narrow. The center of the storm moves with an average velocity of about 9 miles an hour, but the most disastrous storm of recent years, that of September, 1905, moved with nearly twice this velocity.

It took this storm a little less than one day to cross the archipelago. The center of the typhoon passed over the surveying steamer "Pathfinder," then on the east coast of Samar. The barometer reached 27.16 ins., the lowest ever recorded in the islands; it fell 1 in. in half an hour. It is usually possible to predict the approach of a typhoon some time in advance.

The population of the islands in 1903 was about 7,600,000, of whom nine-tenths were classed as civilized; approximately one-fourth of those over ten years of age are able to read some language. There were about 8,000 Americans in the islands and some 41,000 Chinese. The great mass of the people are of Malay origin; they much resemble the Japanese in complexion and general appearance. For a large number of Filipino men in Manila the average weight was 117 lbs. and the average height 5 ft. 3 ins. The density of population is 66 to the square mile, or 2½ times that of the United States. Japan with an area of 148,000 square miles has 47,000,000 people, and Java with 50,000 square miles has 26,000,000 people, respectively five and eight times the density of population of the Philippines. These islands are situated very similarly to Java, and there seems little reason why they should not be as rich and fertile.

With the exception of the Mohammedan Moros of the southern islands and the mountain tribes, the Filipinos have been Christianized, nominally at least; and in this respect and in their family relations they are perhaps the only oriental people approaching European ideals. The Filipinos are naturally a gentle and courteous people, although in warfare cruel acts have been perpetrated by some of them. Numbers of them have reached a high degree of culture; in the legal profession especially some have shown marked ability. They have had few opportunities for technical education, and in engineering have made almost no showing.

As to their value as laborers the opinions of foreigners differ widely. Within the past few years, however, important engineering works, such as the electric railway system, and the new harbor works of Manila, have been constructed with Filipino labor, with the commendation of those in charge. In the Coast Survey work in the islands, Filipinos have been employed quite successfully, and in two lines especially they have shown aptitude, as draftsmen making the drawings for charts and as sailors on the survey vessels. On the other hand complaint is often made of the difficulty of undertaking or conducting works in the Philippines because of the scarcity of efficient labor.

The people in the provinces are used to a very simple life, can obtain sufficient for their actual needs with a moderate amount of exertion, and have very little ambition to accumulate property. Add to this the natural effect of a tropical climate, and it is not surprising that they are often disinclined to labor steadily in ways to which they are not accustomed. There is little doubt, however, that with fair treatment, patient instruction, and careful regard to the conditions, the Filipino will work faithfully and well. The average wages for ordinary labor in Manila are 50 cts. gold a day, and in the provinces 25 cts.

The health conditions in the Philippines are of course important to the engineer. The islands are in the tropics, but the limited width of the land masses, on all sides surrounded by the sea, results in a moderate climate of a marine character. Yellow fever is unknown, and some diseases, pneumonia and typhoid fever for example, are much rarer than in this country. Cholera, plague and smallpox are serious scourges to the natives, but with proper precautions the foreigner can feel fairly safe from them. Among Americans probably dysentery and malaria cause the most disability; these are both diseases of which the means of transmission are known and which can be guarded against. The average death rate among Americans in the Philippine Islands for the year 1906 was 9⅓ per thousand; the Americans were nearly all living in cities, and this is of course much lower than the average death rate in cities in this country. This is certainly a favorable showing, but allowance must be made for the fact that the Americans in the Philippines include few of the very young or the very old, and that those in ill health usually leave the islands. The white man in good condition who leads a temperate and moderate life can usually remain for some time in the Philippines without inconvenience, but an occasional change to a cooler climate is desirable. A tropical climate has some attractive features; one may live with windows open the year round, there is no need of artificially heated rooms, and the same weight of clothing can be worn at all seasons.

After the transfer of the islands, the government early took up the matter of public works, and among the first laws passed by the Philippine

Commission were appropriations for the improvement of the port of Manila, and for public highways. Most of the governmental engineering works are conducted under the Philippine Department of Commerce; there is a Bureau of Public Works, which has charge of highways, bridges, public buildings, etc. The Bureau of Navigation conducts harbor improvements, builds lighthouses and maintains a marine railway for the repair of government vessels. The Bureau of Posts has charge of the telegraph system. The Bureau of Lands makes surveys of the public lands. There is an expert railroad engineer and an expert architect, advisers to the government in these lines. A capable group of men has been gathered, on an entirely non-partisan system, for these works, as well as for the other technical activities of the government.

A very important engineering work has been the improvement of Manila Harbor. Manila Bay is a magnificent body of water with two clear entrance channels, separated by Corregidor Island, but as the bay is from 25 to 30 miles in diameter it does not afford sufficiently protected anchorage off the city of Manila. The Spanish Government had commenced to build a protected harbor with a breakwater south of the mouth of the Pasig, the river which divides the city of Manila. This has been extended and completed, and another breakwater has been built to protect the anchorage from southwesterly winds; these breakwaters were built of rock quarried at the entrance of the bay. The outer portions are in 30 ft. of water, and a large quantity of rock was required owing to the soft nature of the bottom and the consequent settlement.

A considerable portion of the harbor inside of the breakwater has been dredged to a depth of 30 ft. by means of a powerful hydraulic dredge, the pumped material being used to fill a large shoal area along the shore. Wharves are being built out from this filled area so that vessels may hereafter go to the docks and thus avoid the expensive lightering heretofore necessary. The completion of these harbor works has cost about $3,800,000; a considerable part of this will be offset by the value of the land reclaimed. This work has been done under the direction of army engineers, by American contractors. The same hydraulic dredge has been used to fill the moat around the old walled city of Manila, and also to fill in some low sections of the city. The lower part of the Pasig River below the city bridges has been a very useful harbor for the inter-island class of vessels, and considerable work has been done in dredging this and the entrance channel. Harbor improvements of a lesser character are also in progress at Iloilo and Cebu, the two cities next in commercial importance.

At the time of the American occupation the only railway in the Philippines was a line running northward from Manila for about 120 miles, built by an English company under a Spanish concession. The necessity for better communication through the interior of the islands was early appreciated by the Philippine Government and concessions have recently been granted to American companies for the building of 723 miles of railway, under governmental supervision and in part with a government guarantee. Of these new roads 428 miles are in Luzon, extending the present line to the north, and giving Manila railway connections to the southeast; there are also some detached lines in the rich hemp country of southeastern Luzon; 295 miles are in the islands of Panay, Negros and Cebu, the most important being a line across Panay from south to north. These roads are all to be of 3 ft. 6 ins. gage.

The geography of the Philippines is such that the principal means of transportation will always be by water, but there is no doubt that railways in the separate islands will have a marked effect in developing the country, and also in aiding in good government. They will be one of the most efficient agencies in keeping order. I also believe that railways in the more thickly settled portions of the islands will pay well. The natives like to ride and the local passenger traffic is sure to be heavy. On the present railroad the passenger receipts are an unusually large proportion of the revenues. Work on these new railway projects has now been in active progress for about a year.

An important engineering work carried out by the government is the Benguet Road, built to give an easy means of access to the magnificent mountain country of Benguet Province. This is a beautiful, rolling region about 5,000 ft. above sea level, having a temperature nearly 20° lower than Manila, and with pine forests where one might imagine he was in Montana instead of the tropics. Such a region affords a valuable change of climate, and also gives promise of valuable agricultural and mineral resources.

This road follows a deep canyon for nearly all its length of 27 miles; in even grade and beautiful scenery it compares well with the Swiss mountain roads. The road has been kept well above highwater, and largely on solid rock, and crosses from side to side of the canyon. The rock is in many parts of a very unstable character; in one place the surface had to be cut back to a distance of 800 ft. above the grade line. The maximum grade on the road is 9%.

In the city of Manila itself, some notable engineering works have been carried out or are in progress. In the place of the old Spanish "tranvias" with diminutive cars pulled by native ponies, there is now an up-to-date electric railway system, installed and operated by an American company, using almost entir labor under American superinten company has over 40 miles of track, laid in concrete, and extending to th three sides of the city, and a splend tion with turbine engines, said to b equipped in the Orient. In some city, the streets are so narrow th track is possible, and even then it i places for a vehicle to pass a movin electric railway has been an entire s

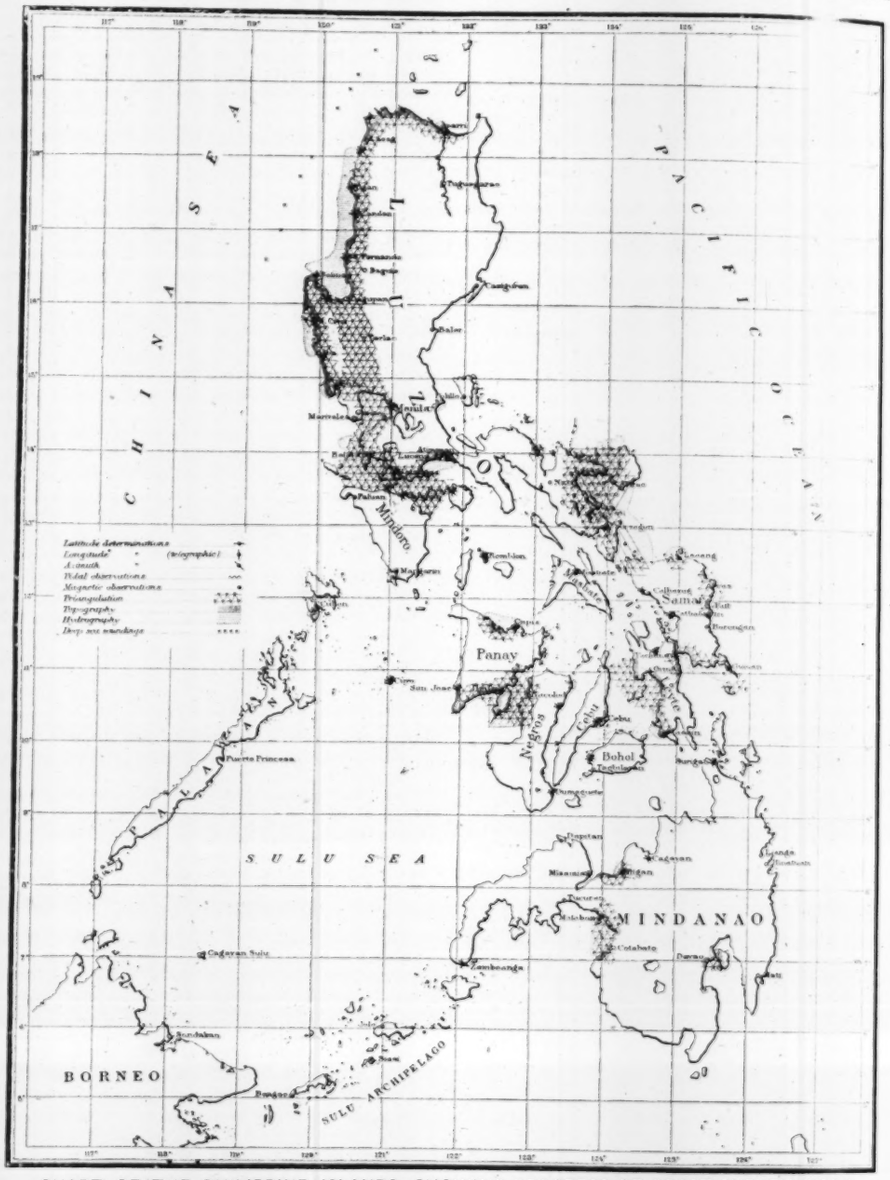

CHART OF THE PHILIPPINE ISLANDS, SHOWING PROGRESS OF COAST SURVEY WORK.

in furnishing good transportation to the city and in being profitable to the company.

The municipality of Manila is now engaged in constructing extensive water and sewer systems, at an estimated cost of about $4,000,000. Manila enjoyed the distinction of having no debt until the issue of bonds for this work. There is an existing water-works built through the generosity of a Spanish gentleman, but this supply has become inadequate and the water is taken from the Mariquina River below a thickly populated region. In the project now under construction the water will be taken from the same river but at a point in the hill country above all the towns. About 23 miles from Manila a dam will be built across this river, forming a reservoir with a capacity of 2 billion gallons. This reservoir will be 212 ft. above sea level and the system will be operated entirely by gravity.

Manila has never been provided with any proper sewerage system. The greater part of the city is very flat and is only a few feet above sea level; in fact in times of great rains and unusually high tides considerable sections of the city have been flooded. The sewerage problem is therefore an important as well as a difficult one. The separate system will be used. For the sewerage it is proposed to have a single discharge into the bay, at a point north of the mouth of the Pasig River, and 6,500 ft. from shore. All of the sewerage will have to be pumped, much of it several times, and pumping stations will be located in various parts of the city. The sewers will start near the surface and obtain the necessary gradient by increase of depth until the pumping station is reached.

Among other engineering works in the Philippines may be enumerated the military works of the army, such as the defenses of Manila and Subic Bays, and various wharves, posts and roads built at military stations, also naval works such as the extensive naval station at Cavite, where several thousand men are employed, and the projected station at Olongapo. At the latter point is located the great floating dry dock Dewey, which was successfully towed to the Orient from Chesapeake Bay.

Prior to the American occupation of the Philippine Islands, the Spanish had published 125 navigational charts, some of which were based on fairly complete surveys, but the greater part were more in the nature of sketches or reconnaissances. British vessels made surveys in the southwestern portion of the islands in 1850 to 1854. The Pacific coasts of the islands were almost completely unsurveyed, largely due undoubtedly to the fact that climatic conditions and the more exposed location increase the difficulty of survey work on the eastern coasts. No systematic survey of the interior of the islands had been undertaken, and the existing maps were not based on instrumental surveys.

Since the transfer of the islands, extensive survey operations have been carried on by the Coast and Geodetic Survey. The military have made numerous reconnaissances for the purpose of improving the existing maps, the naval authorities have made surveys mainly in connection with proposed naval stations, and surveys have been made by the civil authorities of the friar lands purchased by the government and of various projected roads and harbor improvements. A general topographic survey of the islands is much needed, but has not been commenced.

The surveying and charting of the coasts of the Philippine Islands has been considered as an engineering problem, requiring an examination first of the useful existing information, second of the amount of work necessary to be done to furnish suitable charts of the islands, third, of the means available and the methods suitable to do that work.

The existing information consists mainly of the Spanish and British surveys already mentioned. While there were charts covering the entire extent of the islands, an examination of the material indicated that only about 10% of the coasts could be considered chartered with sufficient completeness to meet the present needs of commerce.

After some consideration it was concluded that a fair method of measuring the work to be done and the progress of the work would be by miles of general coast line completed, for this purpose measuring general coast line with three-mile steps of dividers. Thus measured, the Philippines have a coast line of about 11,500 statute miles. Of course one mile of general coast line completed, means all the work required and may include a number of square miles of soundings and of topography. There is also around the Philippines a water area less than 100 fathoms in depth, of 140,000 sq. miles, all of which will require complete hydrographic examination. There is, further, a water area aggregating about 215,000 sq. miles having a general depth of more than 100 fathoms, which will require some examination because of the possibility of shoals. This leaves within the boundary limits a water area of about 230,000 sq. miles which is probably free from dangers or depths affecting navigation. In this connection it is of interest to note that recently a German vessel obtained soundings of over 25,000 ft. only 30 miles from the east coast of the Philippine Islands.

The U. S. Coast and Geodetic Survey commenced field operations in the Philippines in January, 1901, at a time when the insurrection was still in progress, and the whole islands were under military law. At first, work could be done only in or near garrisoned places, but after a few months conditions became much more peaceful and the work has been extended as needed, and no difficulty has ever been experienced with the natives. In December, 1900, a branch office of the Survey was established in Manila, and a plan of cooperation with the Philippine Government was soon after carried into effect.

The logical method of making a complete survey of an extensive region would be first to establish the control points needed or at least to keep a sufficient number of points located in advance of other work, by means of astronomical determinations of position, and of triangulation, and then to fill in the topography and hydrography. Because of the immediate demand for better charts, however, it was necessary to at once begin the hydrographic and topographic work, basing this on such local control as was practicable. Advantage was, however, taken of the military telegraph lines and cables, which had been widely extended, to determine telegraphically the longitude of a considerable number of points, of which the latitude was also obtained. In this way 39 well distributed points were determined, and these have furnished convenient starting points for surveys.

It has been necessary to take up the work in the localities where most needed, the selection depending first on the importance of the region commercially or otherwise, and second on the deficiency of existing charts. It is more efficient to carry such work continuously along a coast, but this has had to be departed from in some instances to meet special demands for surveys. The plan of work has of course been arranged to suit weather conditions, that is during the northeast monsoon work is done on the west and south coasts, and during the southwest monsoon on the north and east coasts. The prevailing winds naturally divide the year into two seasons for survey work, one from May to October, the other from November to April. Except for the time necessary for turning in results and outfitting and repairs between seasons, field work may be done to advantage throughout the year.

The work has been carried on with a wide variety of equipment. Shore parties using native ponies and bull carts for transporation, have done considerable coast topgraphy and triangulation, and this is an economical and efficient method where the country is favorable to working with these means. Hired launches, with parties living ashore, have been extensively used for surveying more protected waters. The greater part of the work, however, has been done with regularly equipped surveying steamers, of which five are now at work in the islands. The largest of these, the "Pathfinder," is a steel vessel which had been used for surveys on the coast of Alaska, and was sent from there to the Philippines. Another steel vessel, the "Fathomer," was built by the Philippine Government for this work. The "Romblon" and "Marinduque," vessels of composite construction, were built in Japan for the Philippine Government, and were later turned over and slightly altered for survey work. The smallest of the five, the "Research," a teak wood steamer, was purchased and altered. The "Fathomer" was specially planned for survey work in the tropics and was described in Engineering News of Sept. 28, 1905. These vessels are all manned with native crews, but the surveying and ship's officers are Americans.

Coast Survey methods have been followed, modified only so far as necessary to meet the conditions. The control consists of longitude and latitude stations determined astronomically, and of triangulation based on an astronomical station, or carried continuously along the coast connecting various astronomical stations. The triangulation furnished the main points which are used for locating minor signals and for filling in the topography and hydrography. It is expected that there will be a main system of triangulation extending the length of the archipelago, and of this nearly one-fourth the distance is now completed. This will form a general basis for the surveys, and for connecting together the various pieces of work. In addition to this main scheme, all the coast work and local surveys are controlled directly by tertiary triangulation.

The topographic work is nearly all done with the plane table, and is confined to the shore line and the important features of the near vicinity. In general the topography has been limited to information that is necessary to show on charts for use in navigation. This of course includes the location and height of hills and mountains visible from the sea, even though some distance inland; these are usually obtained in the triangulation.

The hydrography includes the development of the water area with sufficient detail for the use of navigation. In general the in-shore hydrography has been developed with close sounding lines; while in deeper water the soundings are spaced further apart. The extensive coral reefs arising abruptly out of deep water increase the difficulty of sounding work. In places there are abrupt rocks which may easily be missed by the sounding lead unless great care is exercised. It is of the utmost importance to have all shoals and dangers properly located on the chart. There are sometimes cases, however, of dangers reported as existing which are extremely doubtful, and these doubtful dangers may be in positions on the chart which seriously inconvenience navigation; it is therefore likewise important to investigate such, and if with reasonable certainty they can be proven not to exist they are taken off the chart. There have been several such cases in the Philippines, as for instance Minerva Rock, which a very doubtful report placed as in the entrance to Balayan Bay, and which has been shown on the charts in that position for many years. A careful survey of the vicinity showed no water of less depth than 1,000 ft.

A necessary part of the hydrographic work are the tidal observations, which give the plane of reference to which to reduce all the soundings, and also furnish data on which to predict the tides in advance, such as the predictions published annually in the tide tables. Observations as to currents are also collected, as this information is valuable to navigation. The variation of the magnetic needle is also determined in different localities.

The progress sketch herewith shows the extent of work finished to the end of the fiscal year 1906. About 1,645 miles of general coast line have been completed, and this, added to that which may for the present be accepted from the previous surveys, makes about 25% of the coast line of the islands chartered sufficiently for present needs. The work done includes a narrow fringe of topography along the coast, soundings sometimes carried for a number of miles off the coast, and a triangulation with the points permanently marked and described. Incidentally to the other work, tidal observations have been made at 76 stations and magnetic observations at 56 stations.

A general system of cost keeping has been inaugurated in connection with this work. The total expense for each season of each survey party and vessel is obtained, and this compared with the output of the party; where several different classes of survey operations are carried on by one party the expense is distributed approximately.

The endeavor is to obtain the average costs of survey work so that the cost of future work may be estimated; also to compare the cost of work as done with various classes of equipment, as with shore parties, hired launches and survey vessels; and also to furnish a check on the methods, personnel and organization of the

parties. It is somewhat difficult to select satisfactory units for comparison, as varying conditions affect costs; for hydrography the cost per mile of general coast line, per square mile of area, and per sounding were computed; for topography the cost per mile of general coast line; for triangulation the cost per mile of progress along the axis and per point. In some respects the work could be carried on more economically than in the United States; for instance, native sailors are paid only $10 per month against about four times that much on the Pacific coast, and native laborers only 25 to 50 cts. per day; some materials are also cheaper. On the other hand all skilled assistance must of course be paid higher than in the United States, and all imported materials are more expensive.

A fairly complete survey office has been established and is maintained in Manila where all local arrangements as to the Philippine work are made, and the records are received and put in shape for publication as charts. Manila makes a fortunate headquarters for such work, as it is the commercial as well as political center of the Philippines, and thus it is possible to keep in close touch with the mariners and others for whom the charting work is done, a very valuable relation. In the office at Manila there are employed 6 Americans and about 30 Filipinos. The work there consists of the general business management and of the technical office work, including the computations of astronomical work, triangulation, soundings and tides; the preparation of sailing directions or nautical descriptions of the coasts; and the preparation of the charts. For the latter, the drawings are prepared in Manila, and are sent to the United States for publication. About 16 Filipino draftsmen are employed on this. They are patient and industrious and are excellent penmen, but careful supervision and verification are required. About 90 charts have thus far been published; these are of different scales for various purposes; first there is a general chart of the Philippine Islands on a scale of 1-1,600,000, which is too small for local navigation; there is a series of general charts on four times this scale, or 1-400,000; then there is a series of coast charts on scale 1-100,000, intended for local navigation; then there are special charts on larger scales, of harbors, anchorages, etc. These general schemes of the charts have been planned in advance of the field work. These charts are the main product of the work, but there are incidental by-products of great value, as for instance the triangulation points which can be used in any other surveying or mapping operations.

EXAMINATION QUESTIONS FOR LICENSING ENGINEERS AND SURVEYORS IN THE STATE OF WYOMING.

In our issue of March 28, 1907, we published the text of the law recently passed by the legislature of the State of Wyoming which requires the licensing of all engineers working in the state, such a license to be granted only upon the applicant passing a written examination on technical subjects. The examinations are divided into the following five grades, varying as the importance of the work to be performed: (1) Land Surveyor; (2) Topographic Engineer; (3) Hydraulic and Hydrographic Engineer; (4) Construction and Designing Engineer; (5) Administrative Irrigation Engineer.

This step toward the government regulation of the practice of the engineering profession, a regulation which heretofore has been most generally confined to the professions of law and medicine, is of such importance that the following correspondence from a member of the Board of Examining Engineers, containing a typical set of examination questions, should be of present interest:

Sir: Inclosed you will find some of the preliminary correspondence relating to the examination of engineers and surveyors in Wyoming. You will notice that the typical questions are very simple. This is to protect those surveyors who have only a practical knowledge of the science of surveying. In many parts of the state these men are of great value to the communities in which they live. While their places will be gradually taken by new men who will be obliged to pass a more rigid examination, yet it seems wise to carry the law into effect so as to protect those who are now doing satisfactory work and to gradually improve the profession as settlement takes place. The questions in higher grades than the first will be more difficult because those who desire to qualify in a higher class are men who have such training and experience as will enable them to deal with more technical subjects.

Examinations will be given at about fifty places in the state on June 20 and the Board of Examining Engineers has already secured the assistance of those who will conduct the tests at the various cities and towns.

Sincerely yours,
Clarence T. Johnson,
State Engineer.

STATE OF WYOMING.

Instructions for Conducting Examinations for Engineers and Surveyors.

A person may take examinations in from one to five grades on the same day. Examinations in a higher grade cannot be given until examinations in all grades below it have been completed.

Every person taking the examination must first deposit the sum of $5 with the examiner to cover the expense of issuing his license. This fee is to be forwarded to the secretary of the Board of Examining Engineers with the papers. If a license is issued to any person, his fee will be retained, but if a license is not issued, the fee will be returned. But one license is issued to each engineer or surveyor and it indicates the grades under which he has qualified.

Each applicant for examination should come prepared with pen, ink and ordinary foolscap paper. The examiner will prohibit any reference to books or notes during the examination.

Upon depositing the required fee, the applicant should fill out the blank giving his training and experience, and the examiner will assign him a number on this blank. The applicant should be given the questions in the grades in which he desires to be examined. He should also be instructed not to write his name on any examination papers, but to place at the top of each page its number, the name of the place at which the examination is held, the date and the number assigned him, viz.,

Douglas, Wyo., June 20, 1907. Page 4.
Applicant No. 23.

The time spent upon the examination should be limited to eight hours.

Upon the completion of the examination, the papers showing the training and experience of applicants should be placed in a sealed envelope and sent with all examination papers, by express, collect, to the secretary of the board. The examiner need know nothing whatever of engineering or surveying in order to conduct the examinations. He is to see that the examination is conducted with fairness to all.

(Blank to be filled out by applicant for examination before taking the same.)

Name.....
Address.....
I was born at.....(State or Country).....
.....on the.....day of.....A. D., 18.....
I have lived in Wyoming.....years.

My experience and training in surveying or engineering work has been as follows: (Give particulars in detail as to education, actual work, etc., where employed and by whom.)

If you now practice surveying or engineering exclusively, state the general character of your work.....
.....
Is there a demand for your services in the community in which your work is confined?.....

Witness my hand this....day of.....A. D., 1907.
.....

BOARD OF EXAMINING ENGINEERS.

Examination—Class 1. (Typical Questions.)

1. What seems to be the mean variation of the needle in your locality?
2. How do you determine it?
3. Has the steel tape any advantage over the surveyor's chain? Why do you prefer one or the other?
4. Why does a level bubble stop at the center of the tube when it is leveled?
5. Can you still do good work running levels with the instrument out of adjustment? If so, explain your method.
6. How many acres are there in a field 1,111 ft. square?
7. What is the length and bearing of a line from the center of a section to the northeast corner of that section?
8. What is the least legal subdivision in land surveying?
9. How should the southeast corner of sec. 16 be marked?
10. What are the requirements for a map filed with an application for a permit?

Second Grade.

1. What is the purpose of a topographic survey?
2. What are the advantages of a plane table over a transit for topography?
3. Describe the method you would use in taking contours 300 ft. each side of a ditch already located by stakes.
4. In your experience what is the relative accuracy of work done with transit and stadia and that done with level and tape?
5. The three sides of a right triangle are 125.4, 62.7 and 108.55 ft. Find the angles and the area of the triangle.

Third Grade.

1. Describe a current meter and tell how it is used in measuring a stream?
2. How do you obtain continuous records of the discharge of a stream?
3. What are the several causes of loss of head for water flowing through a pipe under pressure?
4. What are the available and theoretical horsepowers of a stream discharging 23 sec.-ft. over a fall 11½ ft. high?
5. For how many sec.-ft. of water will a certificate of appropriation be issued to cover 83½ acres of

Fourth Grade.

1. Sketch a design for a timber drop in a
2. Sketch a design for a concrete structure at the entrance to a six-foot inverted siphon, for a ditch ft. wide and 4 ft. deep.
3. Give the general form of the prismoidal formula for computing volumes. Is it generally used in computing earthwork? If not, what formula is used?
4. What are the conditions for stability in a type masonry dam?
5. Compute the cost of a retaining wall 1,570 ft. long, 6 ft. high, 4 ft. wide on the bottom, 2 ft. wide on top, with masonry at $4.50 per cu. yd.

Fifth Grade.

1. What is the Carey Act? Why does it encourage investment in irrigation works?
2. What are the two principles governing the control of water in America?
3. Why do court decisions in California not apply to irrigation cases here?
4. What is the purpose and value of a permit under the Wyoming State Law?
5. What is the method of securing a final certificate of appropriation for water stored in reservoirs?

THE FORTIETH ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

With enthusiasm not visibly cooled by the chilly weather which prevailed on the Atlantic Coast, the members of the American Railway Master Mechanics' Association assembled at Atlantic City and, at 9:45 a. m. on Wednesday, June 12, the first session of the fortieth annual convention was called to order by President J. F. Deems, General Superintendent of Motive Power of the New York Central lines.

After the invocation by Rev. N. W. Caldwell, of Atlantic City, Mayor Stoy made a brief address of welcome, which was responded to by Past President A. M. Waitt. The President then delivered his annual address, in which he sketched in a vivid manner the railroad development of this country since, in 1764, "Benjamin Franklin amused himself for three and a half days knitting stockings in a stage coach while going from the Quaker City to New York to sail away to the other side!"

After the conclusion of President Deems' address, and a brief intermission, the business of the Association—minutes, reports of financial committees, membership matters, etc.—was attended to.

TECHNICAL PAPERS, REPORTS AND DISCUSSIONS.

The first technical matter to be brought before the session was then introduced, viz., the report of the Committee on Mechanical Stokers, of which Mr. William Garstang, Superintendent of Motive Power of the C., C., C. & St. L. Ry., is chairman. The report was but a brief one, and contained no definite recommendations, because various stokers are still under test by railroad companies and "the data obtained from these tests are not as yet in sufficiently conclusive shape to make it desirable to present them to the Association." Discussion was made by Messrs. M. K. Barnum (C., B. & Q.), J. F. Walsh (C. & O.) and George F. Hodgins. The report was received and the committee continued.

Shrinkage allowance for tires was next brought up for discussion, the report of the committee on that subject being presented by its chairman, Mr F. J. Cole, Mechanical Engineer of the American Locomotive Co. In this report the recommendations made in 1905 and 1906—principally as itemized below—were renewed:

1.—Shrinkage 1-80 in. per ft. in diameter for cast iron and cast-steel centers less than 66 ins. in diameter.

2.—Shrinkage 1-60 in. per ft. in diameter for centers 66 ins. and over in diameter.

3.—Minimum thickness of tires should be established, due consideration being given to the diameter, service and weight per wheel.

4.—Tire and wheel gages should be of good design, heavy enough to resist bending and subject to frequent inspection to insure accuracy.

5.—72 ins. diameter of wheel center should be included in standard sizes.

6.—Wheel center rims should be preferably uncut; but, if cut, slots should be machined out and closed with solid cast-iron liners driven in. No lead or white metal to be used.

The report was discussed by Messrs. A. M. Waitt and C. A. Seley (C., R. I. & P.); Prof. H. Wade Hibbard, R. R. Div. Mech. Eng. Dept., Cornell; David Brown (D., L. & W.); William

Forsyth (Ry. Age), and W. Garstang. The recommendations of the committee were then referred to a letter ballot of the Association.

The subject next brought up for discussion was that of "Locomotive Lubrication." Mr. D. R. MacBain, Assistant Superintendent of Motive Power, Michigan Central R. R., as Chairman of the Committee on this subject, presented the report. In another portion of this issue we have reprinted the report, which caused a good deal of active discussion upon the part of the members. Those contributing to the discussion were Messrs. W. G. Wallace (Ann Arbor), E. W. Pratt (C. & N. W.), W. G. Menzel (Wis. Cen.), J. J. O. Thomas (Atlantic Coast Line), A. E. Manchester (C. M. & St. P.), J. H. Setchel, Angus Sinclair, William McIntosh (C. of N. J.), and W. H. Lewis (N. & W.).

Considerable argument occurred as to the maximum distance practicable to run a locomotive of a given type upon one pint of oil, anent which phase of the question were cited some cases which Vice-President McIntosh suggested might possibly expand into "fish stories," if allowed to continue *ad libitum*. While from 70 to 80 miles per pint of oil was apparently the accepted standard, cases were mentioned where engineers had run their locomotives 1,000 miles upon a pint of oil without ill effects. Mention was made by Mr. Angus Sinclair of the fact that in his early days of railroading on European lines, when the steam pressure was from 90 to 100 lbs., European engineers thought that cylinder lubrication was quite unnecessary, there being sufficient lubrication in the wet steam to keep valves and pistons from cutting. Internal lubrication of cylinders by oil was frowned upon as a "Yankee invention."

"The Apprentice System on the New York Central Lines," an individual paper by Mr. C. W. Cross, Superintendent of Apprentices for the New York Central Lines, was then brought before the Association. Of all the papers that were presented at this convention, this one stirred up more vigorous and extended discussion than any other. It seemed to be a subject close to the hearts of most of the members of the Association; and the views expressed, and the descriptions of the various systems of instruction in operation on different roads, were exceedingly instructive.

To quote from the opening words of Mr. Cross's paper:

> "The object of this paper is to present briefly the main features of a plan already in successful operation on a large scale, which aims to meet a genuine need in a direct and common-sense manner—a plan worked out primarily to meet the specific needs of a particular group of shops, yet based on general principles that will make it workable anywhere. The purpose of the apprentice system is to provide a motive power department with an adequate recruiting system which will eventually produce from the ranks a large number of skilled workmen, a number of foremen, a sufficient number of good draftsmen, a few master mechanics, and an occasional superintendent of motive power."

After describing in detail the inception of the apprentice course idea on the New York Central Lines, and the inauguration of the system and its development, Mr. Cross went into the question of the effect of such a system upon those enrolled in the classes, the attitude of the men and their interest in the work, the effect of such a system upon the output of the shops, and the attitude of other roads toward the system as operated upon the New York Central.

Mr. W. B. Russell, Assistant Superintendent to Mr. Cross, was a co-writer of the paper in question, and later finished with some interesting side lights upon the situation. Other members who contributed to the discussion were Messrs. A. M. Waitt, who criticized the tendency toward specialization in these courses in that they showed signs of leading to a dearth of good, all-round mechanics in the shops; J. A. Pilcher (N. & W.), who described a somewhat sporadic system in operation in the shops of his line; Harrington Emerson (A. T. & S. F.), who depicted vividly the contrast between the life of an apprentice under such a system and of the life under the old system where the "youngsters" were repressed rather than developed by the men older in the harness; Prof. H. Wade Hibbard, of Cornell, who indorsed the work of the apprentice courses in various shops, and then made the statement that the inauguration of such courses by our railroads was about as severe an arraignment as he had ever heard of our American public school system "in the year of grace 1907." "While we have a few manual training schools in this country," said Prof. Hibbard in effect, "they are so few as to be scarcely felt in the education of mechanics for railroads and the manufacturing industries. The trade schools of Germany, in public education, have made world wide the influence of the stamp 'made in Germany' on manufactured articles." Prof. Hibbard then and later went on to say that the inauguration of such courses in the shops of the railroads did not hurt his graduates in the least, when they elected to take service with the railroads, as suitable and liberal allowances were made by superintendents of apprentice courses for the experience derived in the college courses.

The discussion of this paper extended over a greater time than was expected, and it was deferred until the following day, June 14, when a letter from Prof. W. F. M. Goss, of Purdue University, was presented as a written discussion. Mr. W. Schlacks (Col. Midland) gave an interesting account of a system of apprentice instruction which was instituted on the Illinois Central as far back as 1874, an adaptation of which he and an associate later took to the Denver & Rio Grande R. R. with them and put into operation there.

It will be impossible to give here, owing to lack of space, even a small fraction of the interesting extemporaneous contributions which were made to this question. Suffice to say that the matter was voted upon, and it was decided to place it in the hands of a committee which will present a report upon the question at the next annual convention. The meeting was then adjourned.

At the second session, which was called to order at 9.45 a. m., June 13, the first paper to be presented was the report of the Committee on "The Proper Placing of Flues in High Pressure Boilers." The report was read by the Chairman of the Committee, Mr. C. E. Fuller, Superintendent of Motive Power, Chicago & Alton Ry.; and, although not a long report, it called for quite extended discussion. It was proposed to make a test at Purdue University to determine the relative merits of flues of different sizes, in point of length of service; the motion was voted down, however, in favor of actual service tests. While the practice of various railroads in flue placing was brought before the Association, no definite conclusion or standardization was reached. The report was accepted and the committee continued for another year.

Harrington Emerson, Consulting Engineer for the Atchison, Topeka & Santa Fe Ry., in the absence of its author, Mr. A. Lovell, Superintendent of Motive Power for the same road, read Mr. Lovell's individual paper on "Shop Cost Systems—the Effect of Shop Schedules upon Output and Cost of Locomotive Repairs." This paper was mainly one treating of shop routine, and contained no data in regard to technical developments. The question of slip-shod methods of cost keeping—said to be only too prevalent in a number of railroad shops throughout the country—was heartily condemned, and the adoption of iron-clad systems of cost keeping recommended.

The report of the Committee on "Results of the Use of Different Valve Gears on Locomotives" was read by its Chairman, Mr. C. A. Seley, Mechanical Engineer of the Chicago, Rock Island & Pacific Ry. We have reproduced the report elsewhere in this issue, omitting certain diagrams, and have also made brief editorial comment upon it. Discussion was made by Messrs. F. H. Clark, F. F. Gaines (C. of Ga.), E. A. Miller (N. Y. C. & St. L.), J. H. Manning (D. & H.), Wm. McIntosh (C. of N. J.), and M. E. Wells (W. & L. E.). While it may be a little early to prophesy, it looks, from the tone of the paper and still more from the tone of the discussion, as if the time-honored Stephenson link motion will soon take a back seat in this country for the lighter and more accessible Walschaert gear, already practically the standard on European lines.

Mr. G. W. Pratt (C. & N. W.), in the absence of Chairman T. H. Curtis, of the Committee on "Blanks for Reporting Work on Engines Undergoing Repairs," presented the report of the Committee to the Association. It was merely an outline of blank forms which would facilitate repair work, and did not contain items of technical interest. The Committee was continued for another year's investigation after the acceptance of the report.

A subject of vital interest in railroad circles was that introduced in the report of the Committee on "Development of Motor Cars for Light Passenger Service." The report of the Committee was presented by its chairman, Mr. H. F. Ball, of the American Locomotive Company. It is fair to say that considerable of the field covered by the paper, and some of the cars described, have been treated in previous issues of Engineering News.

The question, "Is it Desirable to Eliminate Water Gage Glasses on Locomotives to Enforce the Use of Gage Cocks," was then opened for topical discussion. Mr. F. F. Gaines, Superintendent of Motive Power, Central of Georgia Ry., first discussed the question, followed by Messrs. A. W. Gibbs (P. R. R.), E. A. Miller (N. Y. C. & St. L.), Wm. McIntosh, David Brown (D. L. & W.), Geo. L. Fowler and W. G. Wallace (Duluth, Missabe & Northern). Objection was made to the gage glass because of difficulty in reading it at night; Mr. Gaines, telling of one of his engineers carrying a lantern for the purpose, said that he had devised a regular gage lamp. Deposition of scale on the interior of the tubes, rendering them difficult if not impossible to read, was given as another objection; suitable modifications in the blowing out arrangement were offered to obviate this. Reliance on the difference in sound between water and steam from gage-cocks at night was questioned by Mr. Fowler, who cited some of his own experiences. Briefly, after many arguments for and against the gage glass, and the use of cocks alone, the prevalent opinion was for the use of both glasses and cocks, their combined use being the strongest available safeguard against accident.

At 9.30 a. m. on Friday, June 14, the third and closing session of the convention was called to order, and an individual paper by Mr. M. E. Wells, Assistant Master Mechanic of the Wheeling & Lake Erie R. R., was presented on "Causes of Leaks in Locomotive Boiler Tubes." In our next issue we shall give a more or less extended abstract of this paper, which contained considerable matter of engineering interest. Those who contributed to the discussion of this paper were Messrs. F. P. Roesch, Master Mechanic of the Southern Ry.; W. E. Symons, of the Pioneer Cast Steel Truck Co.; C. A. Seley, F. M. Whyte (N. Y. C. Lines); H. H. Vaughan (C. P. Ry.); W. G. Menzel (Wis. Cent.), and A. W. Gibbs (P. R. R.).

The next report concerned "Blank Forms to Give the History of Locomotive Movements at Terminals." Mr. G. M. Basford, Assistant to the President of the American Locomotive Company, as Chairman of the Committee on this subject, gave a brief abstract of the report, which, of course, concerned more particularly routine questions than technical ones. It was discussed by a considerable number of the members present.

Another report of a somewhat similar nature—that is, concerning the keeping of records and routine—was an individual paper on "Locomotive Failures, Records and Results of Keeping Them." This paper was prepared by Mr. W. E. Dunham, Master Mechanic of the Chicago & Northwestern Ry., and in his absence was read by Mr. E. W. Pratt, of the same road.

This ended the presentation of reports and technical papers. The Committee on Resolutions then presented its report, which embodied a vote of thanks to those contributing to the success of this year's convention. The resolution was as follows:

> Whereas this Convention has been more than usually successful in attendance, the character of reports and discussions, and in the large number of important and interesting exhibits, therefore, be it
>
> Resolved, That the hearty thanks of the Association be extended to the President for his able and inspiring

address; to the officers of the Association—especially to the Secretary, for his conscientious and efficient service; to the Technical Committee and the authors of papers for their painstaking presentation of subjects for discussion; to the Committee on Arrangements for providing so well for the convention; to the Pennsylvnaia R. R., the Central R. R. of New Jersey, and the Philadelphia & Reading for special trains placed at the disposal of the members, and to the Baldwin Locomotive Works for its kind invitation to visit its plant; to the hotels for their hospitality and comfort provided; to the railroads for courtesies extended; to the Supply Men's Association, and especially to B. V. Crandall, its secretary; to the technical press and especially to "The Daily Railway Age" for interest in and aid of the Association.

ELECTION OF OFFICERS.

The officers elected for the coming year are as follows: President, William McIntosh, Superintendent of Motive Power, Central R. R. of New Jersey; First Vice-President, H. H. Vaughan, Assistant to the Vice-President of the Canadian Pacific Ry.; Second Vice-President, F. H. Clark, General Supt. of Motive Power, Chicago, Burlington & Quincy Railroads; Secretary, Joseph W. Taylor; Treasurer, Angus Sinclair; Executive Members, C. A. Seley (C. R. I. & P.), F. M. Whyte (N. Y. C. Lines), John Howard (N. Y. C. Lines), and A. E. Mitchell (N. Y., H. & H.). After the installation of the newly elected President, the convention was adjourned.

EXHIBITS.

It was said that at this convention the exhibits of the supply men surpassed by far anything that has heretofore been presented. The entire length of the steel pier, from the entrance hall clear out to the sea front, was occupied on both sides by exhibits. There were, all told, more than 280 exhibits this year; and he who would have seen every detail of this vast display must have been argus eyed indeed—though to go the length of the pier and absorb all that was possible was an education in itself. President Deems had this to say, at one of the meetings, of this feature of the convention: "I do not think there has ever been a time when we have had as fine a display of exhibits as we have at this convention. It is a great education to inspect them carefully; they are well worth the time that any one can devote to them." In addition to the exhibits on the pier, four supply companies had track exhibits near the Pennsylvania R. R. station at the foot of Virginia and Mediterranean Avenues.

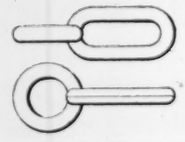

Fig. 1. Old Form of Link, Weldless Chain.

The close affiliation between the American Railway Master Mechanics' Association and the Master Car Builders' Association, and the fact that the two conventions are each year held in conjunction with each other, of course gives the supply men a double opportunity to demonstrate to advantage their various products. The exhibits will remain until the close of the convention of the Master Car Builders' Association, which began on Monday of this week and will be reported in our next issue.

ENTERTAINMENT.

The social side of the convention—by no means the least, as a factor in bringing closer together the delegates and supply men—was admirably administered from start to finish. First-class band music on the pier, both mornings and evenings, took the sting out of the cold weather while it lasted and enhanced the value of the warm weather when it finally arrived. Entertainment for the ladies in attendance at the convention was mainly under the supervision of Mrs. Deems, wife of the retiring President. On Wednesday evening, June 12, an entertainment was given in the ballroom at the Marlborough-Blenheim, followed by informal dancing. On Thursday evening the 40th annual Master Mechanics' grand ball was held in the ballroom on Young's new "Million Dollar Pier," and as a social success was unparalleled in the history of the Association. On Friday evening the delegates were entertained by no less a singer than Madame Schumann-Heink, in the music hall at the outer end of the steel pier; the recital was followed by informal dancing at the Marlborough-Blenheim. At 3 p. m. on Saturday, the eastern supply men pitted themselves against the western in the annual base ball battle, at the Pennsylvania R. R. Inlet Park. The westerners carried a pennant to the field with them, and incidentally it may be added that they returned with the pennant still in their midst. The teams wore distinctive uniforms, and the game had quite a professional flavor.

On Saturday, also, special arrangements were made for conducting a party of the Master Mechanics through the Baldwin Locomotive Works at Philadelphia. Quite a number of delegates availed themselves of this opportunity to visit a representative locomotive plant.

A NEW WELDLESS STEEL CHAIN.

Demonstrations were given last week at the works of the Funk Engineering Co., 47 Fourteenth St., Hoboken, N. J., of a new process of making weldless chains. Similar weldless chains have previously been made, with the form of link shown in Fig. 1. In this type the blanks were stamped and finished ready for bending and slipping together, before the actual assembling of the links. It is seen at once that this necessitated an unsymmetrical link, which was unsatisfactory, especially where the chain was to pass over a wheel.

The new chain is the invention of Stefan K. von Ecseghy, of Vienna, Austria. The secret of making a symmetrical-link weldless chain lies in slipping a blank, from which a new link is to be formed, through the last link already made, as shown in Fig. 2, A. The first two dies press the blank into the shape shown by the plan and elevation in Fig. 2, B. The third die is hinged and bends the blank, formed in the shape shown by Fig. 2, B, around the last completed link, and brings the flat faces (c, c) into contact. There still remains on the newly formed link the webs (a) (b), which are removed by an auxiliary punch press fitted with proper dies. The new link is now complete and ready to receive a blank for a repetition of the process. At present, three movements of the main press are required and two of the auxiliary for the formation of a single link. About 25 seconds are spent in these five movements. This is less than the time required to make a single link of welded chain and can be reduced by making the handling of blanks, links and dies entirely automatic.

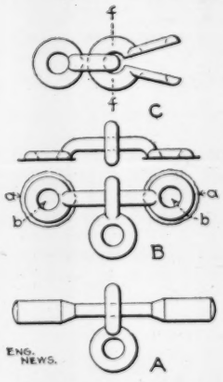

Fig. 2. Steps in the Formation of the New Weldless Chain.

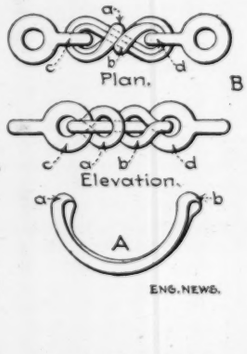

Fig. 3. Method of Repairing the New Weldless Chain.

The extended use of any chain depends somewhat on the ease of repair. For this chain an ingenious method has been devised, which in itself gives a weldless joint. A ring of half-round iron or steel is heated and folded back on itself into the form shown in Fig. 3, A, so that its flat faces are nearly in contact. The end (a), Fig. 3, is passed through the link eye (c). The end (a) is then opened enough so that the other end (b) can be slipped through and the knot drawn to its final position. The end (b) is slipped through the link eye (d), and opened wide enough so that the link (c) knot (a) and any length of chain, of which (c) may be the final link, is passed through. The repair has now the appearance shown by the plan elevation in Fig. 3, B, and may be forged as desired. By this process chains may be made of steel or iron. On account of the greater strength of steel for the same cost, naturally steel material is preferable. Each link eye is made and only large enough to permit a free movement of the links on each other. This renders the chain more compact. A chain made of this stock will have a smaller superficial area than the ordinary chain with the new elongated links.

It will be remembered that the difficulty of making a reliable steel chain of the ordinary type lies in the troublesome heat required for the weld. In this method the blanks are heated only to a cherry red.

Tests made in Sheffield, England, of two nominally ½-in. chains, one of iron and one of steel, gave the following:

	Steel.	Iron.
Diameter	0.52 in.	0.48 in.
Area, cross sec.	0.212 sq. in.	0.181 sq. in.
Elastic limit	55,940 lbs. per sq. in.	36,360 lbs. per sq. in.
Max. load	8.45 tons	4.60 tons
Max. stress	79,720 lbs. per sq. in.	50,840 lbs. per sq. in.
Reduction of area	51.9%	31.0

The patent rights for both process and product are held by the International Import & Export Co., of No. 1 Madison Ave., New York City, to whom we are indebted for this information, and the privilege of witnessing the demonstrations.

NOTES FROM ENGINEERING SCHOOLS.

RENSSELAER POLYTECHNIC INSTITUTE. —The new buildings, Carnegie Hall and William Weightman Walker Laboratory, were dedicated Wednesday, June 12. The address on the opening of Carnegie Hall was made by Mr. Emil Swensson, M. Am. Soc. C. E., of Pittsburg, Pa. The dedicatory address for the Walker Laboratory was given by Dr. William McMurtrie, of New York City, Chief Chemist of the New York Tartar Co., Past President American Chemical Society.

IOWA STATE UNIVERSITY. — Upon the recommendation of the Faculty of the College of Applied Science, the Board of Regents have fixed the degree to be given hereafter to graduating engineering students as Bachelor of Engineering.

Two instructorships have been created, one in civil engineering and one in drawing and descriptive geometry. An extension to the Engineering Building to double its present capacity has been voted by the Regents.

UNIVERSITY OF ILLINOIS.—The College of Engineering has established a regulation that all freshmen and sophomore engineering students shall do a prescribed amount of non-technical reading during the summer vacations. The books must be selected from authorized lists of history, fiction, poetry and general science. A supplementary list has been drawn on which are found works considered both profitable and pleasant. This list contains fiction, biography, works on art, engineering and politics, and is merely recommended. Each man is required to report at the opening of college on books whose credited values aggregate 100 points. The value of the various works ranges from five to fifty points.

THE ORIENTAL LIMITED on the Great Northern Ry. was derailed at Palermo, N. D., 40 miles west of Minot, on June 15. Every car went into the ditch and caught fire. The engineer and fireman were killed and several passengers injured. Spreading rails are the reported cause.

AN ELECTRIC CAR on the Eagle Rock Line, Los Angeles, left the track on June 9 at the curve at Centre Ave. and Colorado St., fell on its side and caused the death of two passengers and the injury of 16 others. The curve is not a sharp one, and the grade is gradual; the rails are reported as not having been displaced, the car seeming, it is said, to have leaped clear of them before overturning.

The motorman, after the accident, reported that the tracks on the down grade approaching the curve were slippery with road-oil which had been sprinkled along the thoroughfare; but officials of the road declare that he violated the rules by not slowing down sufficiently before negotiating the curve.

AT THE HOMESTAKE MINE, Lead, S. D., where the experiment of flooding out a fire by turning in a neighboring creek and other available water was adopted late in April, the work of unwatering the workings has been in progress for three weeks.

The water was shut off from the mine on May 30, when it had reached an elevation of 78 ft. 8 ins. above the 1,250-foot station floor. The time required to fill the mine from the 1,250-foot level to the above mentioned elevation was 42½ days.

While the water had reached the 300-foot level a careful examination was made in the vicinity of the fire, and as considerable gas and heat were still present, although no fire could be seen, the Savage Tunnel and North End Tunnel were bulkheaded and the water allowed to rise above the level.

Examinations were made each day, and it was found that the gas and heat gradually diminished until on May 30 the gas had so far disappeared that every part of the mine accessible was free from it.

The water was shut off, and the skips were immediately put in operation to unwater the mine. Pipes that had been placed in the bulkheads and provided with valves were opened; however, this was not possible at the Savage Tunnel bulkhead, owing to the gas which had accumulated in that tunnel.

The water had on June 9 reached an elevation 10½ ft. below the 300-foot level, and was being skipped out at the rate of 6,500,000 gallons every 24 hours. This rate will soon be increased by the installation of larger skips and air lifts at the Ellison hoist.

We are indebted for the foregoing information to Mr. Bruce C. Yates, Principal Assistant Engineer for the Homestake Mining Co.

HOURS OF LABOR by railway employees in New York are limited by a bill signed by Gov. Hughes on June 17. The bill forbids any railroad company to permit

any employee engaged in or connected with the movement of any train to remain on duty more than 16 consecutive hours or to require or permit any such employee who has been on duty 16 consecutive hours to go on duty without having had at least 8 hours off duty, or to require or permit any such employee who has been on duty 16 hours in the aggregate in any 24-hour period to continue on duty or to go on duty without having had at least 8 hours off duty within such 24-hour period; except when by casualty occurring after such employee has started on his trip, or by unknown casualty occurring before he started on his trip, and except when by accident or unexpected delay of train scheduled to make connection with the train on which such employee is serving, he is prevented from reaching his terminal.

THE OWENS RIVER WATER SUPPLY for Los Angeles was adopted on June 12 by a popular vote sanctioning the issue of $23,000,000 in bonds by the city to cover the cost of the work. The vote was ten to one in favor of the bond issue. The project, which has been under examination by engineers in the employ of the city for two years past, was fully described in our issue of Jan. 24.

THE LARGEST EARTH DAM EVER BUILT is to be undertaken at Standley Lake, about nine miles northwest of Denver, Colo., by the Denver Reservoir Irrigation Co. The dam will be 1¼ miles in length and 150 ft. in height and will thus be a far larger structure than the proposed Gatun dam at Panama. The lake formed behind it will cover about 2,000 acres and will store about 5,000,000,000 cu. ft. of water, enough for the irrigation of over 100,000 acres of land lying below it.

Up to the present time farmers and truck gardeners on the South Platte River, in the neighborhood of Denver, have been entirely dependent on the natural course of the seasons as regards irrigation and the production of crops. There is already in the region an extensive system of but it has not been supplemented by storage facilities of any magnitude.

By the construction of the dam a storage reservoir will be formed which will impound the flow of Clear Creek, South Boulder Creek, Ralston, Coal, Dry, Leyden and Woman Creeks. The present system of ditches will be to a very large extent utilized for distribution from the reservoir, with such additions as may be deemed necessary.

The dam will be constructed by the hydraulic-fill method, the waters of the Farmers High Line ditch, near the site of the dam, being utilized for the purpose. The soil of the hills in the neighborhood is of good depth and eminently well adapted to handling as proposed. About 8,000,000 cu. yds. will be required in the construction, the dam being between 700 and 800 ft. wide at the base. Construction will be commenced during the summer, and it is estimated that three years will suffice for its completion. The cost covering also auxiliary works, is estimated to be between two and three million dollars.

J. G. White & Co., of New York, who have been very largely responsible for making the project an active one, will construct the dam and auxiliary works.

The Denver Reservoir Irrigation Co. is incorporated in the State of Maine, with officers as follows: President, Joseph Standley; First Vice-President and General Manager, W. E. Goldsborough, of J. G. White & Co.; Second Vice-President, T. B. Croke; Treasurer, F. A. Neresheimer; Secretary, O. J. Standley. With the exception of Mr. Goldsborough, all the officers are of Denver and prominent in the banking interests of that city. Mr. O. S. Crane is the Supervising Engineer.

THE SALT WATER FIRE PROTECTION SYSTEM of Key West, Fla., has been reported on by the Committee on Fire Prevention of the National Board of Fire Underwriters (135 William St., New York). Besides being used for fire protection, there are 67 taps on the distribution system, supplying a total domestic consumption of about 20,000 gals. per day used for sanitary flushing purposes, only. Aside from this, the domestic supply for the entire city, with a population estimated at 22,000, is obtained from house cisterns. The fire protection works were built by the city in 1895, when a well 2,200 ft. deep was drilled in the hopes of getting fresh water. The water proved to be salt. It is pumped to a stand-pipe 20 ft. in diameter and 75 ft. high, located 50 ft. from the pumping station. A total of 7.37 miles of tar-coated cast-iron water mains are in use. The report states that the stand-pipe "is very badly corroded, the top sheet being entirely rusted through," and that both its height and storage capacity are inadequate. The committee recommends that a pumping station, with three pumps each having a daily capacity of 2,000,000 gals., be erected on the water front, and that the present pumping station, with two 1,150,000-gal. pumps, be kept in good condition. It is also recommended that direct pumping pressure be maintained, the distribution system strengthened, gate valves added, and an approved type of fire hydrants substituted for those now in use.

"FANS VS. CHIMNEYS" is a question which is often up for discussion when manufacturing and other plants are to be designed. The B. F. Sturtevant Co. is responsible for the following figures concerning the relative efficiencies of chimney and mechanical draft:

Compared with a stack or chimney for producing air movement the fan shows remarkable superiority. The relative efficiency of a fan and a stack or chimney, under ordinary working atmospheric conditions, is shown in the following table:

Relative Efficiency of a Fan Blower and a Stack Discharging Air from the Top; Outside Temperature 60° F.

Height of stack in feet	30	40	50	60
Number of times fan is more efficient than stack:				
Where fan engine exhaust is wasted	20	15	12	10
Where fan engine exhaust is utilized	350	260	210	175

Even at ordinary speed a fan produces a pressure difference so much in excess of that created by a heated stack that far larger volumes may be moved at increased velocity. With internal air as high as 200° and outdoor air at 50° a stack would have to be nearly 600 ft. high to produce the same pressure as that created by a fan at ordinary speed.

The importance of ample air circulation in the drying process is recognized by all. March has always been considered one of the best months for drying. With the stack it is evident that circulation can only be secured by actual waste of heat to the atmosphere, for it is the temperature of the escaping air that governs the velocity. Hence there is a two-fold increase in the waste; the air is both greater in volume and higher in temperature. With the fan, on the other hand, additional air volume costs practically nothing, for all the steam required to operate the fan engine is utilized in the heater and to this extent reduces the amount necessary to be supplied from any other source.

THE NORTH CAROLINA STATE LABORATORY OF Hygiene has for several years past been making analyses of public water supplies and collecting a $60 tax per year from the water-works to pay expenses. In place of a single appropriation of $1,200 from the State to aid in this work, it has recently secured legislation which will result in an annual income of $2,000, besides an increase of $4 per year per water-works, the latter being for the payment of express charges on water samples.

STRENGTHS OF COMMERCIAL TIMBERS of the United States are being determined by tests made by the Bureau of Forestry. Since green timber is weaker than seasoned, the tests are generally made while the material is green.

In the table below are given the breaking strengths (bending) of a number of species, based upon the results of tests; the latter are made upon large beams. The second column of the table gives the greatest load that a beam 5 ins. wide by 12 ins. high, 15 ft. between supports, will carry—the load being concentrated at the central point; with a distributed load, of course, the beam will carry twice the weight given here:

Timber.	Breaking Strength. Lbs. per Sq. In	Max. Conc. Cent. Load for Beam 5 × 12 ins. × 15 ft. Lbs.
Longleaf pine	7,772	20,700
Douglas fir	7,500	20,000
Western hemlock	5,783	15,400
Loblolly pine	5,580	14,900
Tamarack	4,562	12,300
Norway pine	3,975	10,600

THE TOTAL PRODUCTION OF COAL in the United States for 1906, according to statistics compiled for the U. S. Geological Survey by Edw. W. Parker, coal-mining expert in charge, was 414,039,581 short tons of 2,000 lbs.; the valuation on this output is placed at $512,610,744. For the preceding year the corresponding figures were 392,919,341 tons and $476,756,963, respectively, the increases in output and value being 21,120,240 tons and $35,853,781 respectively, or 5.4% and 7.5%.

Pennsylvania alone contributed 48.4% of the output for 1906, or 200,546,084 short tons, valued at 51.1% of the total, or $262,182,935; the excess of the value percentage over the output percentage being, of course, due to the higher value of anthracite—which is produced almost exclusively in that state.

The 1906 statistics put West Virginia in Illinois' former place as the second coal producing state. This is ascribed to labor and wage troubles in Illinois, which seriously impeded production.

For comparison of the relative contributions of the various coal producing states to the totals in output and value the following table is given; the output figures are in tons of 2,000 lbs.:

State.	Production.	Value.
Alabama	13,107,663	$17,467,886
Arkansas	1,864,518	2,999,774
California and Alaska	30,831	78,684
Colorado	10,114,074	12,738,509
Georgia and North Carolina	303,403	407,247
Idaho and Nevada	6,165	24,238
Illinois	41,497,435	44,742,440
Indiana	12,081,281	13,105,168
Indian Territory	2,859,450	5,481,053
Iowa	7,321,639	11,688,598
Kansas	6,040,858	8,935,195
Kentucky	9,673,536	9,794,823
Maryland	5,434,528	6,473,829
Michigan	1,336,338	2,402,529
Missouri	3,765,778	6,163,449
Montana	1,787,938	3,186,620
New Mexico	1,963,558	2,635,571
North Dakota	360,908	437,894
Ohio	27,729,843	30,386,297
Oregon	79,731	212,338
Pennsylvania:		
Anthracite	71,282,411	131,917,694
Bituminous	129,263,673	130,265,241
Tennessee	6,262,686	7,682,121
Texas	1,160,707	2,058,731
Utah	1,773,847	2,411,992
Virginia	4,275,815	4,207,521
Washington	3,276,184	5,908,434
West Virginia	43,276,485	40,777,382
Wyoming	6,138,152	8,019,486
Total	414,039,581	$512,610,744

RECENT GEOLOGICAL SURVEYS IN ALASKA are covered in the report of the U. S. Geological Survey on the mineral resources of Alaska in 1906—just published. This volume, which may be obtained on application to the director of the Survey at Washington, D. C., contains a general account of the progress of surveys and the conditions of the mining industry, by A. H. Brooks, geologist in charge of mineral investigations in Alaska, and a number of detailed reports on various portions of the Territory by other members of the force.

Investigations were made in southeastern Alaska, in the Yakutat-Alsek region, about Controller Bay and Cook Inlet, on Seward Peninsula, and in the Yukon district. These investigations did not relate solely to gold, but comprised examinations of deposits of copper, tin, and other metals, as well as beds of coal, seepages of petroleum, available supplies of building stone and gypsum, and water resources for placer mining.

Less than one-fourth of the area of the Territory has been mapped and less than one-sixth has been surveyed geologically. It is worthy of note that although nearly half a million dollars has been spent on Alaskan surveys and investigations, this is less than one-half of one per cent. of the value of the gold output during the period covered by the surveys.

During the coming season this work is to be continued by eleven parties, which have already been made up and some of which have started for the field of operations. Some of these parties will be so divided in the field that fourteen groups of explorers will be at work in the Territory. The parties comprise twenty technical men (geologists, topographers, and hydrographers) and twenty-one assistants and camp hands.

PLANS FOR NEW DESTROYERS for the U. S. Navy, authorized by the last Congress, have been sent to various shipbuilding companies for bids. The new vessels are to be at least 300 tons heavier than the largest in that class heretofore constructed for the navy; bidders will submit estimates for both reciprocating and turbine engines.

For comparison between these projected destroyers and the largest of the type now in service, these figures may be of interest: The vessels of the "Paul Jones" and "Perry" class—now the largest—displace 480 tons and cost about $285,000; the projected destroyers will be of about 800 tons displacement and are expected to cost in the neighborhood of $800,000.

As to speed, the new vessels will not be as fast as a number of those now in commission—the "Worden" and "Truxton," for example, which figured in the recent race between New York and Newport News, are designed for a maximum speed close to 30 knots an hour—but will be designed for greater coal capacity with consequently increased cruising radius.

THE GREEN MOUNTAIN RACK RAILWAY on Mt. Desert Island, Maine, was built in 1883 and was described in Engineering News of Jan. 22, 1887. It was about 6,300 ft. long and made an ascent of some 1,500 ft. vertically. While the road was successful mechanically, lack of patronage when the popularity of Bar Harbor as a summer resort waned led to its final abandonment in the '90's.

RAILWAYS IN ASIA MINOR are making some progress according to a report from Mr. G. B. Ravndal, U. S. Consul-General at Beirut, Syria. The Damascus & Mecca Ry. is a narrow-gage line being built by Turkish soldiers under the supervision of a German civil engineer, the cost being defrayed by special taxes and voluntary contributions from Moslems in all parts of the world. It is known as the Hamidieh-Hedjaz Railroad, and consists of the main line from Damascus toward Mecca, which is completed beyond Tabouk, some 560 miles, costing about $7,500 per mile, and the Haifa-Derah line of 103 miles, costing about $12,000 per mile, owing to the more irregular surface of the ground. The latter branch is finished and in full operation. On the main line and the Haifa branch there are so far 2,388 bridges of stone and six of metal. Eight tunnels have been bored, and at the principal stations large storehouses and repair shops have been constructed and water supplies established. The rolling stock employed is of Belgian and German origin, while a large portion of the rails were brought from America. It is expected that the main line will reach Medina in a year or more, and Mecca early in 1910. At present trains run regularly as far as Tabouk. Last year the French company operating the Damascus & Beirut Ry. completed an extension to Aleppo. A concession for a railway through Asia Minor and Mesopotamia to Bagdad, on the Persian Gulf, was granted to a German firm in 1899. The road has reached the Taurus Mountains, but construction work is now stopped, as no money is available to pay the mileage guarantee.

A CHICAGO HARBOR PROJECT which is being put forward by Mr. Telford Burnham provides for a lake-front harbor without destroying the lake-front parks and improvements, as in some of the other projects of this kind. The plan proposed is to extend two long piers beyond the mouth of the river, and to have lateral piers on the inner side of each, 500 to 600 ft. long, forming slips or docks for the largest lake steamers. This would be under the protection of the present government breakwater, and another breakwater would protect the entrance. Railway tracks on the piers would connect with the lines now reaching the river, and the intention is to utilize the Chicago River extensively for the collection and distribution of freight. This would eliminate the problem of the difficult and slow navigation of large ships in the narrow river with the swift current required for proper sewage dilution. The project includes the establishment of 14-story warehouses on either side of the river mouth, and a high level bridge connecting the boulevards of the north and south districts of the city.

PERSONALS.

Mr. B. S. Hinckley has been appointed Engineer of Tests of the New York, New Haven & Hartford R. R., with headquarters at New Haven.

Mr. A. D. Bethard has been appointed Assistant General Manager of the Missouri, Kansas & Texas Ry., with headquarters at St. Louis and Dallas.

Mr. John Fritz had conferred upon him by Stevens Institute, at the thirty-fifth Commencement on June 13, the honorary degree of Doctor of Engineering.

Mr. W. F. Harahan, Vice-President of the Illinois Central R. R., is reported to have accepted a position as Assistant to President F. D. Underwood, of the Erie R. R.

At a recent meeting of the Board of Regents of the State University of Iowa, Assistant Professor Byron J. Lambert was appointed Professor of Structural Engineering.

Mr. H. L. Cumming, Assistant Chief Engineer, National Railroad of Mexico, has been appointed Engineer of Maintenance of Way, with headquarters at Colonia Station, Mexico City.

Mr. John W. Hill, M. Am., Soc. C. E., has resigned as Chief Engineer of the City Water Works of Cincinnati. Charles Tudor, Master Mechanic of the Water Department, resigned at the same time.

Maj. Cassius E. Gillette has opened a consulting engineering office at 1031 Land Title Bldg., Philadelphia, Pa. Major Gillette was formerly Chief Engineer of the Bureau of Filtration, City of Philadelphia.

Mr. James M. Reid, Chief Engineer of the National Railroad of Mexico, has been appointed Chief Engineer of Construction of the National Interoceanic, Hidalgo and Northeastern, and the International Railroads.

Mr. Frank T. Gould, formerly with the Bodwell Water Power Co., Old Town, Me., has accepted a position as Assistant Engineer with Westinghouse, Church, Kerr & Co. on the construction of the Pennsylvania Terminal, New York City.

Mr. R. E. Coleman, Superintendent, American Brake Shoe & Foundry Co.'s plant at East Buffalo, N. Y., has become Assistant General Superintendent of the company, with jurisdiction over all its plants. His headquarters will be at Mahwah, N. J.

Messrs. R. C. Huston, former Consulting Engineer for the city of Hattiesburg, Miss., and W. S. Fulton, City Engineer there, have become associated as the Huston Engineering Company, with offices at 613 Macheca Building, New Orleans. The work of the firm will be general engineering and construction work.

Mr. A. S. Ingalls, of Indianapolis, Ind., has been promoted from the superintendency of the Cleveland division of the Cleveland, Cincinnati, Chicago & St. Louis Ry. to the assistant general superintendency of the Lake Shore & Michigan Southern Ry., succeeding Mr. S. W. Brown, who had become General Superintendent of the Michigan Central R. R.

Mr. John E. Field, formerly State Engineer of Colorado, Engineer, U. S. Reclamation Service, in charge of the North Platte Project in Wyoming and Nebraska, and Mr. A. L. Fellows, formerly U. S. Reclamation Service Hydrographer and District Engineer for Colorado, State Engineer of Dakota, will open a consulting engineering office at 319 Symes Bldg., Denver, on July 1.

Mr. Freeland Howe, Jr., Chemist and Bacteriologist of the laboratories at Norway, Me., has been engaged to take charge of the water supply of Bangor, Me. The water is now being treated by mechanical filtration. The filter plant will probably be remodeled and a sedimentation basin added. In connection with the projected work, Mr. George W. Fuller, M. Am., Soc. C. E., New York City, has been consulted.

Mr. Joseph Ripley, M. Am. Soc. C. E., who as Consulting Engineer on the Panama Canal Commission has been designing details of the locks under Col. Goethals, has resigned and will return to the United States. He was Assistant Engineer under former Chief Engineer Stevens, and was a member of the International Board of Consulting Engineers, which met two years ago in Washington to determine the type of canal to be adopted.

Mr. J. M. Graham, Vice-President of the Erie R. R., at the thirty-ninth annual commencement of the Kentucky State College, on June 6, had conferred upon him by President Patterson the honorary degree of Doctor of Engineering. Mr. Graham's most notable work in the engineering field has been on the Baltimore & Ohio and Erie Railroads. On the former road he was the pioneer in inaugurating important improvements in the matter of grade reductions on railroads to increase the train load, and during the five years he was Chief Engineer of that system the line was relocated, changing it from a high-graded road with extremely bad alinement to a road having the most favorable grades of any of the trunk lines between the Atlantic Coast and Chicago and with greatly improved alinement; and a large part of the work had been completed and surveys filed for the balance of the improvements necessary to complete the low-grade line at the time of his leaving. Since his connection with the Erie Railroad, surveys have been made for improvements which will give a line with a maximum ruling gradient eastbound between Cleveland and New York of 10½ feet per mile. Prior to his connection with the Baltimore & Ohio Railroad, on which he was also Superintendent and General Superintendent, as well as Chief Engineer for a number of years, Mr. Graham was General Manager and Chief Engineer of the Northern Pacific & Manitoba R. R., Superintendent and Assistant General Superintendent of the Northern Pacific Ry., and Chief Engineer of various other railroads.

Obituary.

David C. Stewart, one of the pioneer constructors of the Erie R. R., died at his Cleveland home on June 16 of heart failure. He was at one time connected with the old Atlantic & Great Western Ry., which ran between Cleveland and Sharon, Pa.

William LeBaron Jenney, a former leading architect of Chicago and one of the pioneers in modern steel-frame "skyscraper" design, died on June 15 at Los Angeles, Cal. He was born in 1832 at Fairhaven, Mass. In the Civil War he served as an officer of engineers of the staff of Gens. Grant and Sherman, and was Chief Engineer of the Fifteenth Corps at the siege of Vicksburg. In 1905 he retired from active professional practice and moved to Los Angeles.

Henry Garber Hanks, ex-State Mineralogist of California and a scientist of international reputation, died at Alameda, Cal., on June 13. He was born in Cleveland in 1826. In 1862 and 1863 he was Curator of the California Academy of Sciences, and represented the state at the Paris Exposition of 1878; while there he was a member of the first international geological [illegible]ress held there at the time. While State Mineralog[illegible] Californ-nia—1880 to 1886—he organized the State M[illegible] Bureau. He was a fellow of the Geological Socie[illegible] America and of the Geological Society of London, a [illegible]ponding fellow of the Royal Microscopical Society [illegible] of the New Orleans Academy of Sciences, and a m[illegible] of the American Microscopical Society, of which [illegible]as Vice-President in 1898.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN WATER-WORKS ASSOCIATION.
June 17-22. Annual convention at Toronto, [illegible] Secy., J. M. Diven, 14 George St., Charleston, [illegible]

ASSOCIATION OF RAILWAY TELEGRAPH [illegible]PERINTENDENTS.
June 19, 20. Annual meeting at Atlantic [illegible], N. J. Secy., P. W. Drew, Wisconsin Central [illegible], Milwaukee, Wis.

AMERICAN SOCIETY FOR TESTING MATE[illegible]ALS.
June 20-22. Annual meeting at Atlantic [illegible], N. J. Secy., Edgar Marburg, University of Pe[illegible]sylvania, Philadelphia, Pa.

ASSOCIATION OF TRANSPORTATION AND [illegible]AR ACCOUNTING OFFICERS.
June 25, 26. Annual meeting at St. Paul, Minn. Secy., G. P. Conard, 24 Park Place, New York, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 25-28. Annual convention at Niagara Falls, N. Y. Secy., Ralph W. Pope, 29 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
July 1-3. Annual meeting at Cleveland, O. Secy., W. T. Magruder, Ohio State University, Columbus, O.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Annual convention at the City of Mexico, Mexico, beginning July 8. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
July 30-31. First annual meeting at Boston. Secy., Dr. A. H. Elliott, 4 Irving Place, New York.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 7-9. Annual meeting at Norfolk, Va. Secy., Frank P. Foster, Corning, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The program of the twenty-fourth annual convention at Niagara Falls has been published. The list of papers is as follows:

TUESDAY, JUNE 25—President's Address—The Properties of Electrons, Samuel Sheldon; Protective Apparatus Engineering, E. E. F. Creighton; Practical Testing of Commercial Lightning-Arrestors, P. H. Thomas; A Proposed Lightning-Arrestor Test, N. J. Neall; Interaction of Synchronous Machines, Morgan Brooks; Heating of Copper Wires, A. E. Kenelly; Deflocculated Graphite, E. O. Acheson.

WEDNESDAY, JUNE 26.—Under the direction of the High-Tension Transmission Committee. Choke-coils versus Extra Insulation on the End Windings of Transformers, S. M. Kintner; Protection of Internal Insulation of a Static Transformer Against High Frequency Strains, W. S. Moody; Transmission Lines and Economical Spans, D. R. Scholes; Lightning Rods and Grounded Cables as a Means of Protecting Transmission Lines Against Lightning, N. S. Rowe; The Transmission Plant of the Niagara, Lockport and Ontario Power Co., R. D. Mershon; Location of Broken Insulators and Other Transmission Line Troubles, L. C. Nicholson; A New Type of Insulator for High Tension Transmission Lines, E. M. Hewlett; New Methods in High-Tension Line Construction, H. W. Buck; Switchboard Practice for Voltages of 60,000 and Upward, S. Q. Hayes; Power Transmission Economics, F. G. Baum; One-Phase High-Tension Power Transmission, E. J. Young; The Application of Oil Switches in Power Transmission Work, D. B. Rushmore.

THURSDAY, JUNE 27.—Single-Phase vs. Three-Phase Generation for Single-Phase Railways, N. W. Storer; The Choice of Frequency for Single-Phase Alternating-Current Motors, A. H. Armstrong; Report of the Committee on a Code of Ethics; The Attitude of the Technical Schools toward the Profesison of Electrical Engineering, H. H. Norris; the Concentric Method of Teaching Electrical Engineering, V. Karapetoff; Report of the Standardization Committee.

FRIDAY, JUNE 28.—Track-circuit Signaling on Electrified Roads, L. F. Howard; Regeneration of Power with Single-Phase Electric Railway Motors, Wm. Cooper; Transformer Testing, H. W. Tobey; Inductive Disturbances in Telephone Lines, Louis Cohen; Fractional Pitch Windings for Induction Motors and Alternators, C. A. Adams, W. K. Cabot, G. A. E. Irving, Jr.; Power-Factor, Alternating Current Inductive Capacity, Chemical and Other Tests of Rubber Covered Wires of Different Manufactures, H. W. Fisher; The Vector Diagram of the Compensated Single-Phase Alternating Current Motor, W. I. Slichter; Zigzag Leakage of Induction Motors, R. E. Hellmund.